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Ichthyofauna from the Jasło Shales of Sobniów

(Ichthyofauna łupków jasielskich z Sobniowa)

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ICHTHYOFAUNA FROM THE JASŁO SHALES OF SOBNIÓW (THE CARPATHIAN FLYSCH)

Abstract: A description of Oligocene fish remains from the Jasło shales of Sobniów. Eight species are differentiated, belonging to the families of Clupeidae, Gonostomidae, Sternoptychidae, Myctophidae, Carangidae, Cybiidae and Cottidae. Two new species are described: *Idrissia carpathica* belonging to the Gonostomidae, and *Polyipnus sobniowiensis* belonging to the Sternoptychidae. The greatest consideration is given to systematics and anatomy. Characteristic of the ichthyofauna from the Jasło shales is the mass occurrence of bathypelagic fishes with luminous organs. Their presence justifies the assignment of these shales to deep-sea deposits.

INTRODUCTION

The abundance of fossil fish remains in the Carpathians is, as a rule, associated with menilitic shale series. This statement is correlated with the history of investigations of ichthyofauna from the Polish Carpathians (Heckel 1850), (Kramberger 1879), (Rychlicki 1909), (Bośniacki 1911), (Böhm 1930). The fish remains studied by those authors were obtained from menilitic shales and, with rare exceptions, from sandstones. The complete list of species and genera so far recorded from the Polish Carpathians (Jerzmańska 1958) does not, according to the more recent views on systematics (Weiler 1935, 1938), (Pauca 1934), reveal great differentiation of forms, although quantitatively some forms may be regarded as common.

On the other hand, the greater part of the still undescribed fossil fish remains from the Jasło shales contains many new forms not previously reported from the Carpathian Flysch. They have been preserved as skeletons with fin rays and outlines of the soft body parts — in fact, in representatives of the Myctophidae and Sternoptychidae, even

with traces of the luminous organs. Hence, the greatest attention is given in the present paper to anatomy and systematics.

The lack of scales in the majority of remains — except those from the genera *Clupea* L. and *Equula* Cuv. — is a characteristic feature of the manner of preservation of fish remains from the Jasło shales. Only more or less distinct traces of scales are detectable in all the other forms here considered, while detached scales are extremely rare.

The presence of some detached heads, belonging only to representatives of the Clupeidae and Sternoptychidae, may be of some interest.

GEOLOGICAL CHARACTERISTICS OF THE JASŁO SHALES FROM SOBNIÓW

During recent years, the Jasło shales — an important index horizon in view of the extreme monotony of the Krosno beds — have attracted the particular attention of many geologists (Świdziński 1947), (Jucha 1957,) (Jucha, Kotlarczyk 1959), (Koszarski, Żytko 1959). Within the central Carpathians, these shales occupy varying positions above the top of the menilite shales. According to Świdziński (1947), the Jasło shales occur as thin intercalations in the upper part of the middle Krosno beds.

At least two lithologically distinct horizons may be differentiated within the Jasło shales (Jucha, Kotlarczyk 1959), (Koszarski, Żytko 1959). The lower of the two is thicker and more widely distributed. These horizons are composed of a varying number of layers of limestone shales and limestones. The lower horizon is distinctly laminated, while the upper is unlaminated. Koszarski and Żytko (1959) assume the presence in the Jasło shales of still another (median) horizon. The distance from the upper to the lower horizon of the Jasło shales varies from a score or so to above 100 m.

The differentiation of the Jasło shale horizons has so far been based primarily on lithological characters; some difficulty is therefore encountered in defining their position in the horizontal section. Consequently, an investigation of the ichthyofauna from these shales will probably provide suggestions useful for the clarification of stratigraphic problems.

The fish remains here considered have been obtained from that part of the Jasło shales which Jucha and Kotlarczyk (1959) recognized as the lower horizon (former B horizon of Jucha, 1957). They were collected in the village of Sobniów, about 3 km SE from Jasło. The position of these shales is shown in the geologic sketch map (Fig. 1;

after Jucha 1957), in a fragmentary outcrop on the NE pit wall of a brick-yard still being worked. The shales occur in the top of the pit as a thin layer extending well over 1.5 m in length. They are of a light-brown color, distinctly laminated, calcareous, turning white under weathering. No important differences can be observed under the microscope. Both the vertical and horizontal distribution of the fish remains occurring abundantly is on the whole uniform.

Field investigations at Sobniów, subsidized by the Institute of Paleozoology of the Polish Academy of Sciences in Warsaw, were carried on throughout 1956 and 1958. Some 250 specimens were collected — sufficiently well preserved to permit systematic studies — together with a few plant remains.

Several other specimens from the same fossiliferous locality have been kindly presented to the Paleozoological Laboratory of the Wrocław University by Dr. St. Kadyi of Jasło, Mr. Koziński — a teacher at the Primary School of Sobniów, and Stanisław Jucha of the Academy of Mining and Metallurgy of Cracow.

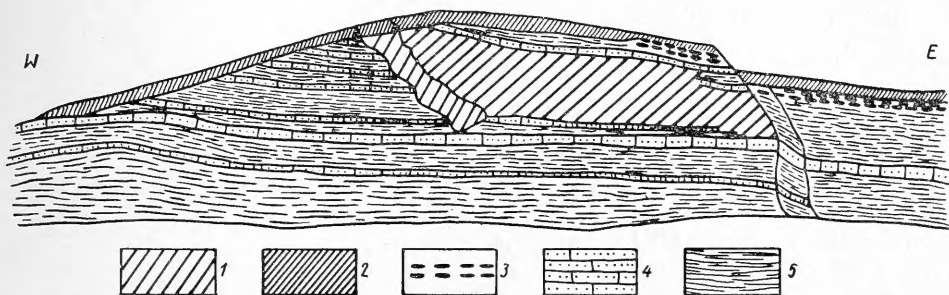


Fig. 1. Outcrop of the Krosno Beds with the Jasło Shales in the village Sobniów. (according to Jucha, 1957, p. 524) 1 — landslide, 2 — soil, 3 — Jasło shale, 4 — sandstone, 5 — gray shale.

All the 263 specimens, obtained from the outcrop at Sobniów were registered as a single collection, labeled with the symbol Os. and consecutively numbered.

Cordial thanks are due from the writer to: Professor R. Kozłowski, Head of the Institute of Paleozoology of the Polish Academy of Sciences in Warsaw, for help in obtaining the grant which facilitated the writer's study of fishes from the Carpathian Flysch; to Professor Zb. Ryziewicz, Head of the Paleozoological Laboratory of Wrocław University, under whose general guidance the present work was completed; to Docent Vl. Kalabis of the Masaryk University in Brno for

his friendly assistance to the writer during her visit to Czechoslovakia, the kind loan of material and books, the helpful comments on the Myctophidae material here considered, and suggestions concerning the fossil representatives of the Sternoptychidae.

Dr. Wl. Strojny kindly undertook the photography.

THE SYSTEMATICS

The species and genera represented in the material here considered¹

Order Clupeiformes

Suborder Clupeoidei Cuvier, 1817

Family Clupeidae Bonaparte, 1831

Genus *Clupea* Linné, 1758

Clupea sardiniites Heckel

Suborder Stomiatoidei

Family Gonostomidae Goode and Bean, 1895

Genus *Idrissia* Arambourg, 1959

Idrissia carpathica n. sp.

Family Sternoptychidae Günther, 1864

Genus *Polyipnus* Günther, 1887

Polyipnus sobnioviensis n. sp.

Order Scopeliformes

Family Myctophidae Gill, 1893

Genus *Eomyctophum* Danilchenko, 1947

Eomyctophum menneri Danilchenko

Eomyctophum cf. *koraensis* Danilchenko

Order Perciformes

Suborder Percoidei Cuvier, 1817

Family Carangidae Günther, 1860

Genus *Equula* Cuvier, 1815

Equula ? sp.

Suborder Scombroidei

Family Cybiidae, Kishinouye, 1915

Genus *Sarda* Cuvier, 1829

Sarda sp.

¹ After Berg's (1955) Systematics.

Suborder Cottoidei Agassiz, 1834

Family Cottidae Swainson, 1839

Genus indet.

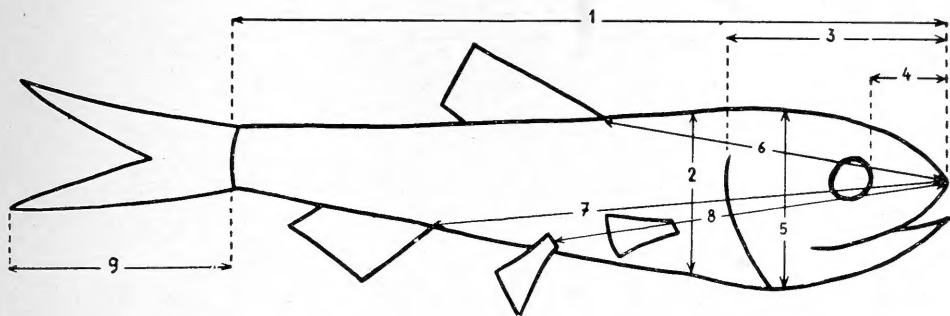


Fig. 2. Diagrammatic drawing of fish with dimensions: 1 — length without caudal fin, 2 — depth of body, 3 — length of head to posterior margin of operculum, 4 — preorbital area, 5 — depth of head, 6 — predorsal area, 7 — preanal area, 8 — preventral area, 9 — length of caudal fin.

Descriptions

Order **Clupeiformes**

Suborder **Clupeoidei**

Family **Clupeidae**

Genus *Clupea* Linné, 1758

Clupea sardinites Heckel, 1850

(Pl. V, Fig. 1; Pl. VI, Fig. 1)

1850. *Meletta longimana* (Heck.); J. J. Heckel, Beiträge... p. 231, Pl. 25
1850. *Meletta crenata* (Heck.); J. J. Heckel, Ibid., p. 233, Pl. 26
1850. *Meletta sardinites* (Hesk.); J. J. Heckel, Ibid., p. 277, Pl. 23, 24
1934. *Clupea longimana* (Heck.); M. Pauca, Die fossile Fauna... p. 601—
—2, Pl. 1, Fig. 3a, b; Pl. 5, Fig. 2, 5.
1934. *Clupea sardinites* (Heck.); M. Pauca, Ibid., p. 603—4, Fig. 7, Pl. 1,
Fig. 1.
1938. *Clupea sardinites* (Heck.); W. Weiler, Neue Untersuchungen...
p. 11—12.

Material: 6 complete, fairly well preserved skeletons, and 13 skulls, some with a part of the trunk; one headless trunk (166. Os.).

Dimensions of two, most completely preserved specimens (in mm)
 No. 159. Os. No. 161. Os.

Body-length without caudal fin	40.0	67.9
Greatest depth of body	9.0	12.8
Length of the head to posterior margin of operculum	11.8	21.3
Depth of the head	8.0	14.2
Length of caudal fin	7.4	12.7

Description. The greatest depth of body fits 4.4—5.3 times into the body-length without the caudal fin. All the specimens are arcuately curved, the head and forebody turned upwards. The length of the head fits about 3.3 times into the body-length without the caudal fin. The quadrato-mandibular articulation below the anterior margin of the orbit.

The vertebral column consists of about 43 vertebrae, including 13 caudal (counting from the end to the 1st interhaemale). The ribs begin from the 17th vertebra (from the back). Dorsally, there are all along the vertebral column thin but rather long intermuscular bones².

The pectoral fins consisting of 13—14 rays occur immediately behind the head.

The ventral fins are situated 4—5 vertebrae after the 1st ray of the dorsal fin, below the 23rd—25th vertebra (from the back). They consist of about 8 rays.

The dorsal fin begins above the 27th—29th vertebra (counting from the back). Its base has the length of 7 precaudal vertebrae. There are 15—17 rays.

The anal fin is on the whole unsatisfactorily preserved. On specimen 159. Os 17 rays may be seen; the first of them below the 12th vertebra, the last below the 3rd vertebra (from the back).

The caudal fin deeply notched, with 9 cardinal and 6 side rays.

The scales are partly preserved. Even the keel scales are seen on specimen 117. Os.

In addition to specimens of *Clupea sardinites* Heck., detached scales of the genus *Clupea* sp. are encountered which may have belonged to individuals of *C. sardinites* Heck.

The scarcity of *C. sardinites* Heck. within the Jasło shales is a very

² French arêtes musculaires, German Muskel-Gräten.

characteristic feature of these sediments, in sharp contrast to the menillite shales in which the Clupeidae are extremely common.

Suborder **Stomiatoidei**

Family **Gonostomidae**

Genus *Idrissia* Arambourg, 1954

Idrissia carpathica n. sp.

(Figs. 3, 4; Pl. I, Pl. V, Fig. 2)

Diagnosis. 38—39 vertebrae (including 15 caudal), P* about 14, V 6—8, D 10—11, A 13—14, C 10, 11—11, 10. Body narrow, head large, jaws with sharply pointed conical teeth. Dorsal fin begins at the middle of the body (without the caudal fin) or close by after it. Ventral fins occur below the last rays of the dorsal fin. The anal fin is placed 8—9 vertebrae behind the last ray of the dorsal fin.

Material: 31 skeletons, including 19 complete or nearly complete, the remainder more or less fragmentary. Some of the most completely preserved specimens display more marked flattening and elongation of the head and body, most likely due to diagenetic processes. The exact body dimensions could be determined only on measurements taken of 8 most satisfactorily preserved specimens of various sizes. (Nos. 28. Os., 42. Os., 45. Os., 46. Os., 73. Os., 77. Os., 164 Os., 187. Os.); of these, 164. Os. was selected as the holotype, and Nos. 28. Os., 45. Os., 77. Os. and 187. Os. as the paratypes.

Table 1 specifies the dimensions of the holotype, the paratypes and — for the sake of comparison — (after Arambourg, 1954) those of *Idrissia jubae* Aramb., the only species thus far known from this genus.

Description. These fishes are characterized by a rather narrow body. The greatest depth fits 4.1 to 6.2 times (15.1—24.2 percent) into the body length — without the caudal fin. In *Idrissia carpathica*, the long head, characteristic of this genus, fits 2.9 to 3.2 times into the body length — without the caudal fin. The orbital diameter exceeds the preorbital area, with the exception of the case of a young specimen (No. 42 Os.) in which these two values are almost the same. The diameter of the orbit fits about 3 times into the head length, to the posterior margin of the operculum. When comparing the head structure of *I. jubae* Aramb. with that of *I. carpathica* n. sp. it is clearly seen that the preorbital area in the latter form is larger.

* Fins: P — pectoral, V — ventral, D — dorsal, A — anal, C — caudal.

Table 1

Dimensions of *Idrissia carpathica* n. sp. and *I. jubae* Aramb. (in mm)

Dimensions	<i>Idrissia carpathica</i> n.sp.					<i>Idrissia jubae</i> Aramb.*	
	Holo- type 164. Os.	Paratypes				T. 135	T. 196
		187. Os.	28. Os.	77. Os.	45. Os.		
Length of body without caudal fin	56.5	ca. 44.5	31.7	49.5	26.9	50.0	40.0
Greatest depth of body	11.3	ca. 10.8	6.5	8.2	6.0	11.0	10.0
Length of head to posterior margin of operculum	17.9	13.6	10.0	15.6	8.4	16.0	16.0
Preorbital area	5.4	3.9	2.2	3.8	2.2	5.0	5.0 ?
Horizontal diameter of orbit	5.3	4.7	3.9	5.2	2.7	5.0 ?	5.0 ?
Predorsal area	30.0	22.9	15.9	26.2	13.6	28.0	22.0
Preanal area	44.5	—	24.7	40.2	20.6	?	34.0
Preventral area	34.5	—	17.8	29.8	15.9	30.0	25.0
Length of caudal fin	12.3	—	7.8	12.7	—	11.0	10.0

* Vide Arambourg 1954.

Skull. A narrow, long parasphenoid is the most distinctly preserved part of the neurocranium. The other bones are, on the whole, poorly preserved. Conical teeth may be seen on the maxillary bone of cranium viscerale of several specimens (Nos. 191. Os., 85. Os., 185. Os.). Unfortunately, neither the maxillary nor the premaxillary bone has been found on any of the specimens. The shape and dentition of the dentary, however, are quite distinctly seen on nearly all specimens. This is a strong, stout bone (in length equal to twice the maximum depth), the posterior margin not reaching to the line which centrally traverses the orbit. The dentition of the dentary consists of small, even, sharp, closely spaced conical teeth which seem smaller than the teeth on the maxillary bone.

The operculum is large, with thickened anterior margin and slanting ventral margin, showing some slight corrugations parallel to the ventral margin (Fig. 3). These corrugations, however, do not occur on all the specimens, and therefore cannot be regarded as an index feature. The long, upper and lower branches of the preoperculum are placed at almost a right angle one to another. The anterior margin of the upper branch shows marked thickening. The interoperculum is not clearly outlined, but it also must have been fairly large. According to Arambourg (1954), the marked development of the gill covers in the genus *Idrissia* suggests some association with the Elopidae.

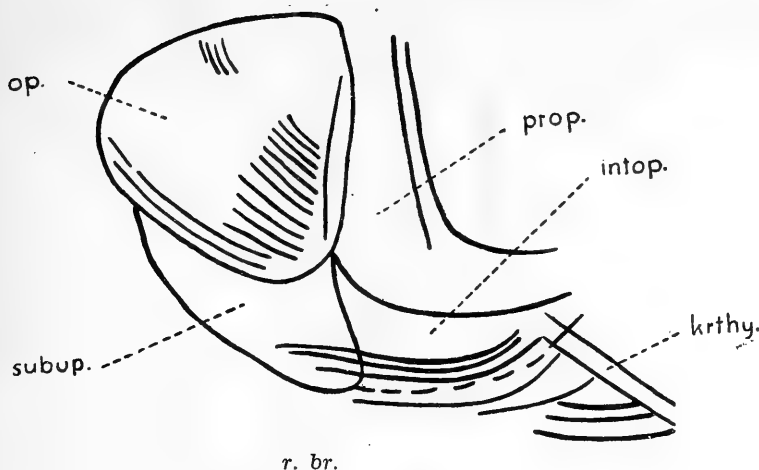


Fig. 3 *Idrissia carpathica* n. sp. opercula (after specimen No. 46, Os) ca. x 7.

intop. interoperculum, *krthy.* keratohyal, *op.* operculum, *prop.* praeoperculum, *r. br.* radii branchiostegii, *subop.* suboperculum.

In the oral cavity of specimen 187 Os., the caudal end of some smaller fish can be seen clearly indicating the predatory manner of life of *I. carpathica*.

The vertebral column consists of 38—39 vertebrae (of which 15 are caudal). The length of the last five caudal vertebrae is equal to their depth; nearer to the front of the body, the caudals and the precaudals grow longer. In *Idrissia jubae* Aramb. the last five caudals are likewise strongly shortened (Arambourg 1954). In specimens of *I. carpathica*, these caudals are but slightly reduced in length as compared with the other vertebrae. An upturned urostyle and numerous hypural plates are seen on the end of the vertebral column (Fig. 4). The neurapophyses of the caudals are long, thin, reaching almost to the dorsal border of the body, while the neurapophyses of the precaudals are shorter, in some individuals apparently thicker. The ribs are thin but long, reaching almost to the ventral border of the body. Heamapophyses at first short, but gradually longer, occur in the caudal part. Similarly to the case of *I. jubae* Aramb. long, thin intermuscular bones occur in the forebody, beginning from the 18th vertebra (from the back), and are placed at a sharp angle in relation to the centrum.

The pectoral fins are placed immediately behind the head, low down on the ventral border of the body. They are narrow and long, in length corresponding to 8—10 precaudal vertebrae, and consisting of about 14 soft rays. In *Idrissia jubae* Aramb., the number of these

rays — 18—20 — is greater. This marked variability concerning the number of rays in pectoral fins of congeneric species is also recorded in living representatives of the Gonostomidae. For example, there may be 11—13 rays in *Gonostoma elongatum* Günther, and only 7—10 rays in *G. bathyphilum* (Vaillant), as reported by Norman, 1930.

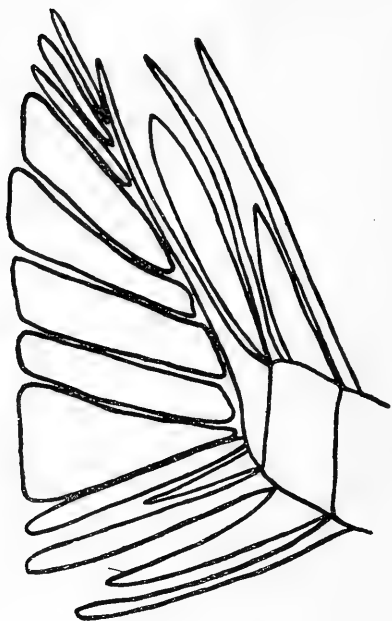


Fig. 4. *Idrissia carpathica* n. sp., ending of the vertebral column (after specimen No. 87 Os.) ca x 20.

Elements of the shoulder girdle could not be distinguished owing to the bad state of preservation of the material.

The ventral fins are excellently preserved on several specimens. They consist of 10 rays corresponding in length to 6—8 precaudals; in some individuals, the rays reach almost to the beginning of the anal fin. The ventral fins are placed below the last rays of the dorsal fin (below the 22—23rd vertebra from the back). The preventral area (Table 1) represents 56—60 percent of the body length — exclusive of the caudal fin — except that in specimen 46. Os., where it represents no more than 54 percent of the body length and where the ventral fins occur below the mid-part of the dorsal fin. The dorsal fin, consisting of 10—

11 rays, is best preserved in specimen No. 85 Os. It begins at mid-body length or just beyond (above the 25th—27th vertebra counting from the back). The predorsal area is equal to 50—53 percent of the body length (without the caudal fin). The base of this fin corresponds to the length of about 5 precaudal vertebrae. The length of the rays, as compared with the body depth at the beginning of this fin, is as follows: the length of the first ray represents two-thirds of the body depth, the second ray is nearly as long, the third and the fourth rays have the greatest length, which exceeds the body depth by about one third, while the next rays are gradually reduced.

The interneuralia are weak, most satisfactorily preserved on specimen No. 87 Os. It seems that, in front of the interneuralium which supports the first ray, there is another free one, more obliquely placed

in relation to the dorsal margin of the body. The last ray has no corresponding interneuralium.

The anal fin. The rays here, some 13—14 in number, are thinner than those in the dorsal fin; the first two extremely short, similarly as in *Idrissia jubae*. The interhaemalia thin, about 11—12 in number, absent in the first and last rays. The best preserved anal fins are on specimen 164 Os. (holotype), 77 Os. (paratype) and 87 Os. The base of that fin corresponds to the length of 6—7 caudal vertebrae. Its beginning occurs far behind the dorsal fin, below the 13th—14th vertebra (from the back). The distance between the last ray of the dorsal fin and the first ray of the anal fin corresponds to the length of 8—9 precaudals. The preanal area represents 76—81 percent of the body length without the caudal fin. The narrow alimentary canal terminates just before the anal fin; in all the specimens available it is well preserved as a black organic substance.

The caudal fin. Strongly notched, consisting of 11 strong cardinal rays and 10 short side rays (in each lobe), most satisfactorily preserved on specimens Nos. 164. Os. (holotype) and 87. Os. The length of the longest rays represents about 20 percent of the body length without the caudal fin.

The whole body was covered by scales the traces of which have persisted only as faintly indicated impressions. Some of the specimens bear pigment spots, as a rule restricted to the upper half of the body; just a few may occur ventrally near to the base of the caudal fin.

General remarks. A comparative study of the species described above with the fossil representatives of Gonostomidae, previously recorded, justifies its assignment to the genus *Idrissia* Aramb., described from the Upper Cretaceous of North Africa (Arambourg, 1954). Until now, this was a monotypic genus, represented by *Idrissia jubae* Aramb. The differences between the two species are shown in Table 2.

According to Arambourg (1954), the beginning of the development of the Gonostomidae occurred during the Cretaceous, since the oldest thus far known representatives of this family are the Cretaceous genera *Idrissia* Aramb. and *Paravinciguerrria* Aramb. Arambourg supposes that they represent extremely primitive forms; in spite of the lack of photophores, he connects *Paravinciguerrria* Aramb. with the living genus *Vinciguerrria* Goode and Bean. The fossil remains of the latter, with photophores preserved, are known as early as from the Oligocene (Danilchenko, 1946).

In arrangement of fins and number of rays on the dorsal and anal fins, the living genus *Ichthyococcus* Bonaparte from the Gonostomidae seems to approach *Idrissia* Aramb., another of the most ancient

genera of that family. Owing to inadequate knowledge concerning the osteology of *Ichthyococcus* Bonaparte, differences thus far reported between these genera primarily concern the body dimensions; in adult individuals of *Ichthyococcus* Bonaparte, the relation of the body depth to the body length considerably exceeds that in *Idrissia* Aramb. According to Brauer (1906), however, the body depth in young individuals of genus *Ichthyococcus* Bonaparte is distinctly smaller, while a compar-

Table 2

Comparison of characters of *Idrissia jubae* Aramb. and. *I. carpathica* n. sp.

Character	<i>Idrissia jubae</i> Aramb.	<i>Idrissia carpathica</i> n. sp.
End of obliquely oriented snout	below the center of orbit	not reaching the center of orbit
Dentary	low	high (maximum height equal to half its length)
Length of preorbital portion	equal to diameter of orbit	less than diameter of orbit
Postorbital portion	about one-third of head length	exceeds one-third of head length
Number of vertebrae	40	38—39
Last 5 caudal vertebrae	strongly reduced	slightly reduced
Neurapophyses	short	long
Number of rays in pectoral fins	18—20	ca. 14
Length of pectoral fins expressed in length of precaudal fins	ca. 5	ca. 8—10
Position of ventral fins	approx. below the center of dorsal fin	below last rays of dorsal fin*
Predorsal area in percents of body length without caudal fin	55—56%	50—53%
Number of rays in dorsal fin	13	10—11
Preanal area in percents of body length without caudal fin	85%	75—81%
Number of rays in caudal fin	9	11
Number of side rays in caudal fin	2—4	10

* Exceptionally in one individual the ventral fins are vertically placed below the center of dorsal fin.

ison of young forms with genus *Idrissia* Aramb. reveals a rather close resemblance in the shape of body.

The other evolutionary line of the Gonostomidae may possibly also be traced back to the Cretaceous, from the genus *Idrissia* Aramb. to the living representatives of *Ichthyococcus* Bonaparte. These suppositions cannot be accepted until the osteology of the genus *Ichthyococcus* is adequately known, and remains of *Idrissia* — with the luminous organs preserved — are discovered.

Family **Sternoptychidae**

Genus *Polyipnus* Günther, 1887

Polyipnus sobnioviensis n. sp.

(Figs. 5, 6; Pl. II; Pl. III, Fig. 1)

Diagnosis. 31—33 vertebrae (of which 19—20 are caudal), P 10, V 7—8, D10—11, A18—20, C5—6—10—10—5—6. Maximum body depth quite close to the head; no spines before the dorsal fin. The predorsal area represents 48—56 percent of the body length without the caudal fin. The anal fin begins below the last rays of the dorsal fin or just beyond them. The luminous organs in distinctly differentiated groups: subcaudal, anal, preanal and abdominal. The group of supra-abdominal organs consists of 4 detached photophores.

Material. 70 skeletons showing body-outline and traces of photophores; of these, 26 specimens are complete and have served for the computation of the variability range of the body dimensions. The collected material also contains 7 heads broken off from the body, most likely conspecific. Only one headless body has been found. Specimen

Table 3
Dimensions of *P. sobnioviensis* n. sp. (in mm)

Dimensions	Holo- type	Paratypes					
	49. Os.	124. Os.	260. Os.	232. Os.	157. Os.	128. Os.	
Length of body without caudal fin	23.1	22.9	21.9	18.0	33.4	29.9	
Depth of body immediately behind head	9.5	9.2	9.5	6.7	9.6	8.1	
Depth of body at beginning of dorsal fin	9.4	9.1	8.5	—	8.2	6.5	
Depth of body at beginning of anal fin	6.4	7.1	7.4	—	6.5	6.1	
Length of head to posterior margin of operculum	8.5	7.6	7.6	6.2	10.7	10.3	
Depth of head	10.1	10.3	—	7.9	10.4	9.0	
Predorsal area	12.3	12.3	12.0	—	12.5	16.7	
Length of caudal fin	6.6	7.7	6.0	5.5	8.5	7.9	

49. Os. has been selected as the holotype, while the paratypes are represented by Nos. 124. Os., 128 Os., 157. Os. (the largest individual), 232. Os. (the smallest individual) and 260. Os. Dimensions of these individuals specifies Table 3.

Description. The species here considered represent small-sized fishes — the length of the largest specimen is 33.4 mm without the caudal fin. The body is laterally compressed with the greatest depth immediately behind the head, and narrowing up gradually without abrupt curves in the ventral profile, so characteristic of the genus *Argyropelecus* Cocco or *Sternoptyx* Harm. The greatest depth of body fits 2.3 to 3.6 times in to the body length without the caudal fin; i.e. the depth of body represents 27—43 percent of the body length without the caudal fin. Hence some specimens seem short and deep others considerably more slender and longer. Plate II presents the deepest individuals of this species, Plate III, Fig. 1 shows the most slender. There is no distinct predominance of the "deeper" forms over the "more slender" or vice versa. If some, arbitrarily selected, groups be differentiated among the variability range given above, the respective numbers of individuals (as based on the 26 complete specimens) are as follows:

Group	Number of individuals	Relation of maximum body depth to length without caudal fin (percent)
I	8	27—30
II	4	30—35
III	8	35—40
IV	6	40—43

Skull. In 21 individuals the length of skull represents 32—36 percent of the body length without the caudal fin, in one individual 28 percent, in two 30 percent, in one 38 percent and in another 39.9 percent.

In the neurocranium, in addition to the parasphenoid (Fig. 5) fairly broad frontalia can also be seen. The inadequate state of preservation of the other bones does not permit the particular elements to be distinguished.

A long, posteriorly, gently arcuate maxillare, with a narrow, likewise arched supramaxillare, is to be observed in the cranium viscerale of many individuals. The anterior part of the mouth opening is rimmed by the narrow, elongated premaxillare. In numerous specimens, the presence has been noted of minute, conical denticles along the whole length of the lower margin of the premaxillare, as well as in

the posterior part of the maxillare. In the lower jaw, similar denticles occur along the entire length of the upper margin of the dentary. The narrow, arcuate pterygoid is placed above the upper jaw. The keratohyale with numerous radii branchiostegii occurs on the prolongation of the maxillare.

The deep operculum (Fig. 5) is the best developed of the bones of the gill covers. The preoperculum occurs as an extremely narrow, elongated bone without spines. Another, similarly narrow bone, can

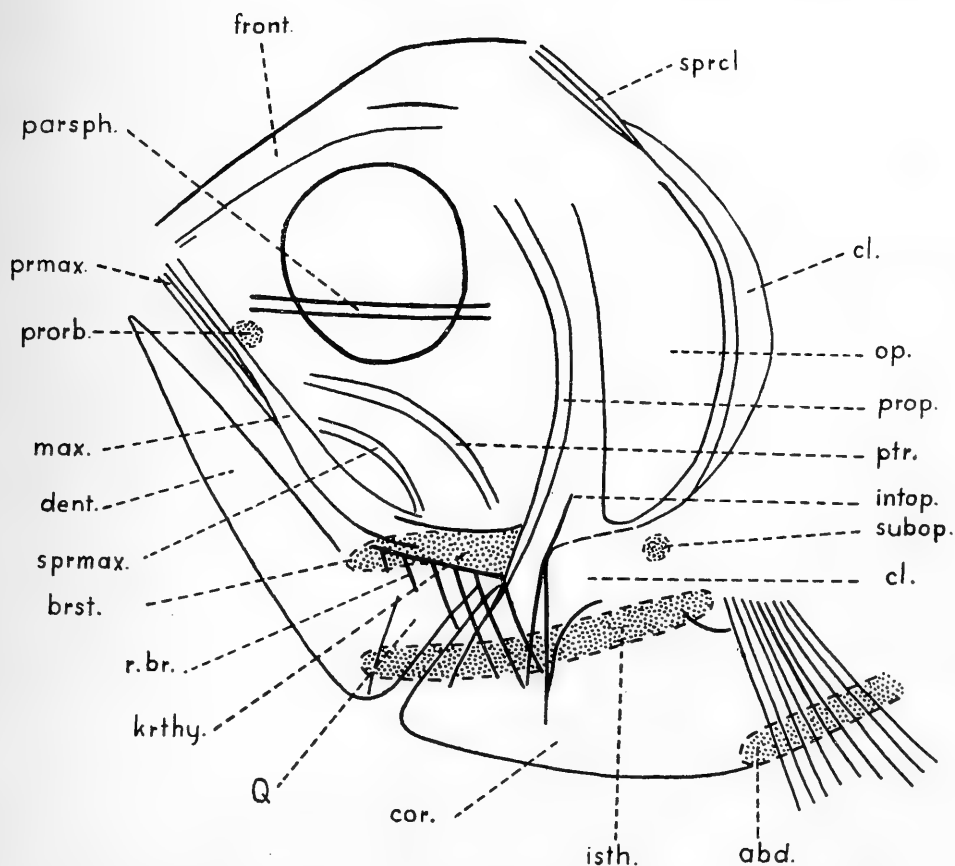


Fig. 5. *Polyipnus sobnioviensis* n. sp., skull (after specimen No. 124. Os); luminous organs reconstructed after specimens Nos. 124. Or. and others ca. x 10.

abd. abdominal organs, brst. branchiostegal organs, cl. cleithrum, cor. coracoideum, dent. dentary, front. frontale, intop. interoperculum, isth. organs on the isthmus, krthy. keratohyale, max. maxillare, op. operculum, prorb. preorbital organ, subop. subopercular organ, parsph. parasphenoid, prop. preoperculum, prmax. praemaxillare, ptr. pterygoid, Q — quadratum, r. br. radii branchiostegii, sprmax. supramaxillare, sprcl. supracleithrum.

be seen on specimen 124. Os., with some probability identifiable as the interoperculum. The above pattern of the gill covers suggests some resemblance to the living genus *Sternoptyx* Harm., which also has a long narrow preoperculum and interoperculum (Gregory, 1933, 1957).

The vertebral column consists of 31—33 vertebrae; of the 26 complete specimens available, one half has 32 vertebrae, ten individuals have 31 and but three have 33 vertebrae. As a rule, there are 19—20 caudals. In the precaudal part, they are nearly as deep as they are long, while in the caudal area their length slightly exceeds the depth. An exception here are the last and the penultimate vertebrae (from the end) which are distinctly shorter. The vertebral column terminates in an upraised urostyle. The hypurals are not very distinctly preserved, but it may be reasonably supposed that the rays on the lower lobe of the caudal fin are supported by at least one, very broad hypural, while in the upper lobe this support is provided by several smaller hypurals. The neurapophyses and hemapophyses are long and narrow. The presence of long, thin intermuscular bones is confined to the precaudal portion of the vertebral column, both dorsally and ventrally (Fig. 6); moreover, on some of the specimens they cannot be seen at all.

The ribs, which are long and thin, reach almost to the ventral margin; there are 8—9 pairs of them. The last pair always belongs to the 22nd or 23rd vertebra (from the back). The first two pairs of the ribs, placed immediately behind the head, are always the shortest.

The pectoral fins are situated low down, immediately behind the head. Owing to the state of preservation, the exact number of rays cannot be determined; the probable figure is 10.

A large coracoideum, satisfactorily preserved on all specimens, is the best developed element of the shoulder girdle (Fig. 5), while the scapula cannot be discerned. Of the dermal bones the cleithrum has a somewhat characteristic shape, but only its upper, arcuately bent part has been preserved on many specimens. On some specimens, in the proximity of the keratohyal and the preoperculum, there is an expanded bone, terminating in a long spine (Fig. 5); by analogy with the structure of the cleithrum in the living genus *Argyropelecus* (Gregory 1933, 1957), the present writer supposes that it is the fore part of the cleithrum.

The ventral fins are short, about 2.0—2.5 mm in length, with the exception of those on the largest specimen (No. 157. Os.) which are 3.4 mm long. They probably consisted of 7—8 rays and were vertically arranged below the 21st—23rd vertebrae (from the back), close below or in front of the first rays of the dorsal fin (Fig. 6). The pelvic bones are delicate, satisfactorily preserved in the largest individual (157. Os.).

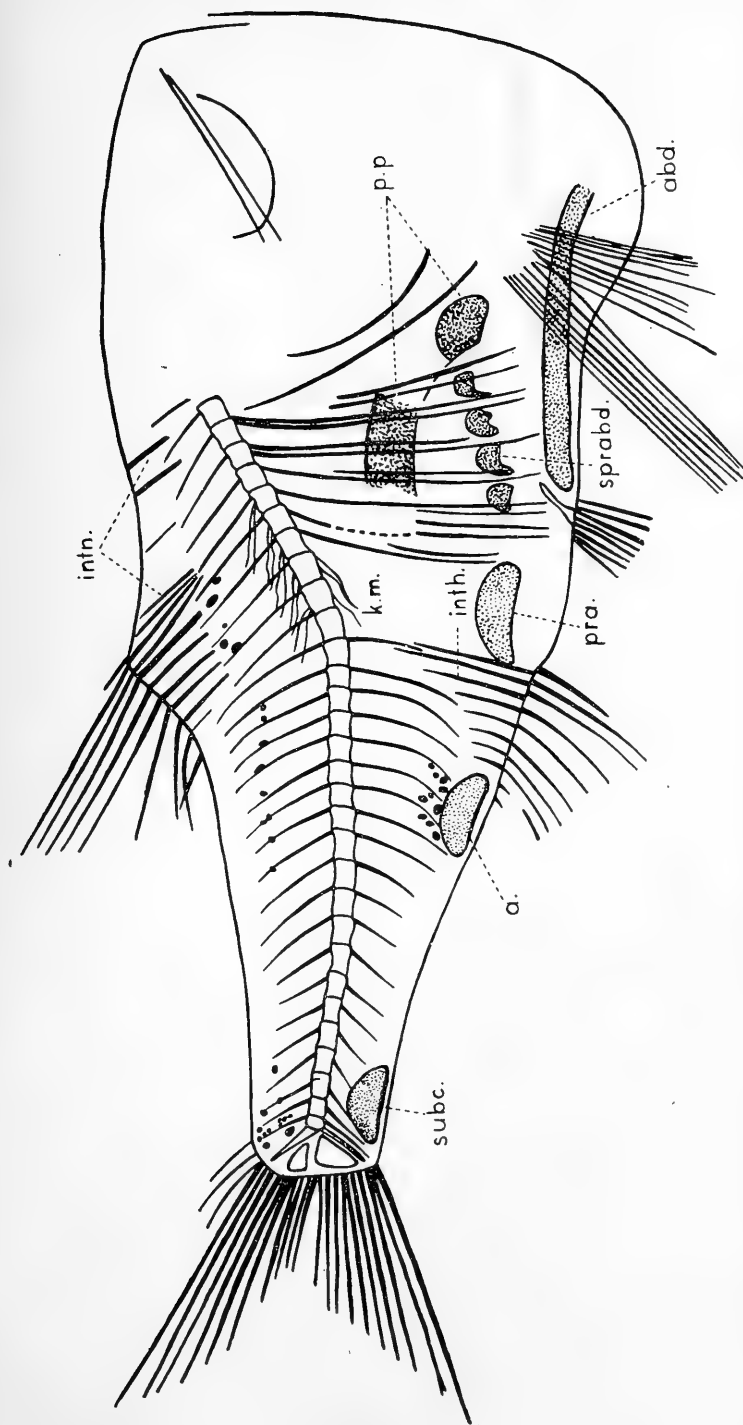


Fig. 6. *Polyipnus sobniovienensis* n. sp. (after specimen No. 260. Os) ca. x 6.7. a. anal organs, abd. abdominal organs, inth, interhaemal, intn. interhaemal, k. m. (intermuscular bones,) p.p. alimentary canal, prae. preanal organs, sprabd. suprabdominal organs, subc. subcaudal organs.

The dorsal fin. Since the dorsal profile is slightly raised at the beginning of this fin, the dorsal fin occurs on a more or less distinct elevation (Fig. 6; Plate II, Plate III, Fig. 1). The first ray is vertically oriented above the 20th—22nd vertebra (from the back). The dorsal fin consists of 10—11 rays of which the 1st is the shortest, the 3rd and the 4th the longest, while the subsequent ones are gradually reduced. All these rays, the last 1—2 excepted, are supported by long narrow interneuralia. There is one free interneurium immediately before the 1st ray of this fin; moreover, 3—5 small narrow bones occur further ahead in some specimens (157. Os., 260 Os.); these are likewise regarded by the writer as free interneuralia (Fig. 6). The base of the dorsal fin corresponds in length with that of 4—5 precaudal vertebrae.

No paired spines — by Schultz (1938) regarded as one of the generic index characters for *Polyipnus* Günther — have been observed before the first ray of the dorsal fin on any of the specimens available. However, according to the description and illustration of *P. fraseri* by Flower (1934) this species also lacks paired spines before the dorsal fin.

The predorsal area — as measured from the beginning of the snout to the base of the 1st dorsal fin ray — represents in 22 specimens 48—56 percent of the body length (without the caudal fin), 57.1 and 59.1 percent respectively in two other individuals, and 37.1 percent in one specimen only.

The anal fin. Position in relation to the dorsal fin varies: the beginning may either be vertically oriented below the last ray of the dorsal fin, or it may be slightly shifted to the front or to the rear (by the length of about 2 vertebrae). The long anal fin consists of 18—20 rays, out of which only the first ten, rather strong rays, are on the whole well preserved, while the subsequent rays are, owing to their fragility, distinct only on very few specimens. The length of a well preserved anal fin is equivalent to that of 9—10 caudal vertebrae. The first rays are strong and long (about 5 mm), they occur below the 16th—20th vertebra (going from the end), while the subsequent ones gradually grow shorter and weaker. Similarly, the first interhaemalia are the longest and strongest, the subsequent ones are gradually reduced, while the last extremely delicate ones, are completely obscured by the accumulation of pigment in the group of anal photophores.

The caudal fin is deeply notched, each lobe consisting of 10 cardinal and 5—6 shorter side rays. The side rays have been preserved only on some specimens.

The luminous organs are well preserved as spots of pigment, which correspond to the groups of the respective photophores. In some cases, it is even possible to determine the probable number of photophores

contained by the particular groups. The writer's description of the luminous organs is based on the nomenclature of Schultz (1938).

After Brauer (1908), two fundamental types of luminous organs may be distinguished in the living representatives of the Sternoptychidae:

(1) single photophores which are broad and laterally strongly flattened, and

(2) groups of photophores, formed by the fusion of several luminous organs.

Fossil photophores, only partly preserved, are recorded among remains of *Argyropelecus bullockii* David (David 1943). In representatives of *Polyipnus sobniowiensis*, the writer has encountered traces of pigment which are the vestiges of the next luminous organs.

Skull: (1) a detached preorbital organ, placed below the level of the parasphenoid in front of the orbit; it is satisfactorily preserved on specimen 156. Os and certain others; (2) a detached subopercular organ, best seen on specimen 56. Os., lying at the back of the head in the prolongation of the branchiostegal photophores; (3) a group of branchiostegal organs — the faintest traces, frequently fragmentary — most readily discernible on specimen 56. Os. and situated in the fore part of the head, near the keratohyale; (4) a group of organs on the isthmus; this is a fairly large group somewhat obliquely oriented within an area from the quadratum to the pectoral fins.

The trunk: (5) group of abdominal organs; this is the largest group of low photophores, which begins before the pectoral fins and terminates at the base of the ventral fins; (6) a group of supraabdominal organs, consisting of 4 distinct, large, detached photophores which lie above the last photophores of the abdominal group; (7) a group of preanal photophores, which lie before the beginning of the anal fin and constitute a clearly delimited, deep group which has been adequately preserved in all individuals; (8) a group of anal photophores, longer than the preanal group, beginning between the 8th and the 9th rays of the anal fin; the detectable traces reasonably suggest the occurrence in this group of 6—8 detached photophores; (9) a group of subcaudal photophores, lying far toward the rear of the body and reaching to the base of the first side rays in the lower lobe of the caudal fin.

The body of the individuals here investigated is bare, devoid of the traces of scales. Two fairly large groups of minute spots of pigment (Fig. 6), distributed near the caudal fin and in the central part of the body, have been observed above the vertebral column of certain spec-

imens. Similar tiny spots are also occasionally encountered in the vicinity of the anal photophores.

General remarks. The fossil remains of the genus *Polyipnus* have not been previously reported. The only exception is a brief mention (Kalabis, 1948) concerning the discovery, within the manilite shales of Moravia, of one representative of the Sternoptychidae. According to Kalabis, this may either represent the genus *Polyipnus* or belong to some new genus. In view of the lack of comparable fossil material of the genus *Polyipnus*, the present writer had to base her studies on zoological literature which deals but incompletely with the problems of skeletal structure (Gregory, 1933, 1957), (Schultz 1938), (Fowler, 1934).

As has already been stated, in the structure of the gill covers, the Sobniów remains resemble the genus *Sternoptyx* Harm., but differ from it in the absence of a broad and high spine before the dorsal fin, and the position of the fins. According to Brauer (1906), independently from body shape variations the ventral fins and the beginning of the caudal fin in this genus always occur before the first rays of the dorsal fin. Its only fossil species, *Sternoptyx prisca* Pauca from the Oligocene of Rumania, which is represented by 5 specimens (Pauca, 1931, 1933), also differs in structure from the Sobniów remains.

On the other hand, a strong resemblance has been noted by the writer to the genus *Argyropelecus* Cocco as regards the structure of the humeral girdle; the specimens she examined differ, however, in the structure of the dorsal fin which — in Brauer's (1906) opinion — invariably begins before the anal fin, while its anterior portion, consisting

Table 4

Comparison of characters of *P. fraseri* Fowler and *P. sobnioviensis* n. sp.

Character	<i>Polyipnus fraseri</i> Fowler	<i>Polyipnus sobnio- viensis</i> n. sp.
Occipital spines	very strong *	missing
Preoperculum	with two spines	without spines
Number of rays in anal fin	11	18—20
Number of photophores of the anal group	4	6—8
Photophores of the abdominal group	begin beyond base of pectoral fins	begin before base of pectoral fins

* on this character, Fowler (1934) referred *P. fraseri* to a new subgenus *Acanthopolyipnus*; this opinion, however, did not meet with general approval and was criticized by Parr (1937).

of 7—9 rays, has been modified into a broad denticulate crest. Neither do the fossil species *Argyropelecus logerati* Aramb. (Arambourg 1929) and *A. bullockii* David (David 1943) display any similarities with the material under investigation.

The remaining (third) genus *Polyipnus* Günther³ with which we have to deal, apparently comes closest despite a few differences, to the remains here examined, in body shape, structure of fins and, above all in the arrangement of the luminous organs — a character of maximum significance. The satisfactory state of preservation of the luminous organs did, indeed, make possible a comparison in this respect of the fossil and living representatives. Among the several species known in recent fauna, *Polyipnus fraseri* Fowler (Fowler, 1934) comes nearest to the Sobniów remains in the distribution of the luminous organs. In this species the preanal, anal and subcaudal photophores occur in three groups, similiary as in *P. sobnioviensis*. Another common character is the presence of 10 rays in the dorsal fin, also the lack of paired spines before the first rays of this fin.

The two species just mentioned differ, however, in fundamental characters, as in shown in Table 4. These differences bar the assignment of the Sobniów forms to *P. fraseri* Fowler, necessitating the establishment of a new species: *Polyipnus sobnioviensis*.

Order Scopeliformes

Family Myctophidae

Genus *Eomyctophum* Danilchenko, 1947

(Figs. 7—11; Pl.III, Fig.2)

1947. *Eomyctophum* Danil.; P. G. Danilchenko, Ryby semeistva Myctophidae., p. 193—196 Figs. 1, 2.

This is the only genus of the Myctophidae represented in the Jasło shales of Sobniów, and at the same time the dominating form in our collection. It is represented by small fishes with well preserved luminous organs.

The skull. Viewed from the inside on all specimens. (Fig. 7). The orbit rather large, displaying specific variability, more or less anteriorly

³ The recent monotypic *Snellius* Koumans — represented by *S. boschmai* Koumans — which was described in 1953, is the 4th genus of the Sternoptychidae. In view of lack of adequate literature, it could not be included by the writer in her comparison of the fossil and recent representatives of this family.

placed, most commonly almost completely filled by a black substance. The particular elements of the neurocranium cannot be distinguished, since as a rule the bone boundaries are not indicated. Hence, only the general contour of the skull is shown in Fig. 7.

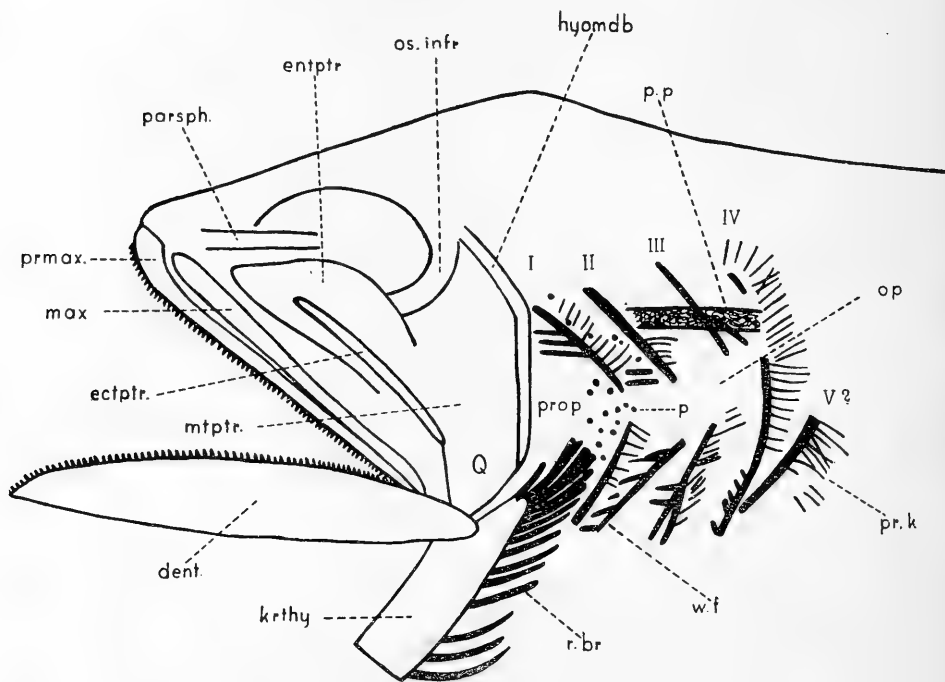


Fig. 7. *Eomyctophum menneri* Danil., skull (after specimen No. 17 Os.); ca x 8.6. dent. dentary, ectptr. ectopterygoideum, entptr. entopterygoideum, hyomdb. hyomandibulare, krthy. keratohyale, mtptr. metapterygoideum, max. maxillare, op. operculum, os. infr. ossa infraorbitalia, p. pigment, parsph. parasphenoideum, prop. praeoperculum, pp. alimentary canal, pr. k. osseous rods, prmax. praemaxillare, Q — quadratum, r. br. radii branchiostegii, w. f. filtration process, I — IV gill arches, V probably an element of 5th gill archa.

A long, narrow, premaxillary bone which rims the upper border of the snout is very clearly indicated within the cranium viscerale. The long, narrow maxillary bone overlies it. On many specimens minute, densely spaced denticles occur on the premaxillary bone and on the long, strongly developed dentary of the lower jaw. The mouth opening of all species reaches beyond the posterior border of the orbit.

In our material, the skeleton of the gill apparatus is represented by fragmentary remains of the gill arches. On these are very distinctly seen osseous rods which support the gill lobes (Fig. 7), and relatively

strong filtration processes which undoubtedly indicate that the genus *Eomyctophum* belonged to forms feeding on plankton.

Of considerable interest in these Oligocene forms would be the occurrence of gill lobes, whose presence in the lower part of arch V may be reasonably postulated by reason of the satisfactory state of preservation of the gill arches in specimen 17. Os. An indication of this might be found in the osseous rods — representing the skeleton — present on that part of the arch which probably belongs to gill arch V. No such gill lobes are encountered on arch V in the recent bony fishes.

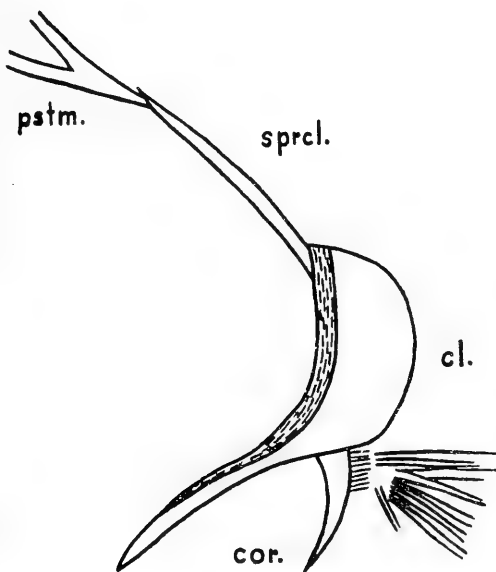


Fig. 8. *Eomyctophum* cf. *koraensis* Danil., elements of shoulder girdle (after specimen 55. Os.). ca $\times 8$

cor. coracoid, ol. oleithrum,
pstm. posttemporale, sprcl. supracleithrum.

Only the inner surface of the gill covers can be seen so that a reconstruction of their shape is hardly possible. If not all, at least the operculum, was coated by scales which are preserved as impressions over a small fragment in specimens Nos. 70. Os. and 177. Os. The shoulder girdle (Fig. 8) occurs immediately behind the posterior border of the operculum, the cleithrum being its most prominent part. The coracoid is the only visible bone of cartilaginous origin. The scapula

is not detectable. Above the cleithrum lies the long, narrow supracleithrum which, in turn, joins with the bifurcating posttemporale.

The vertebral column consists of a varying number of vertebrae, ranging in the particular species from 28 to 32. These rather few vertebrae seem very characteristic of the genus *Eomyctophum* Danil., since other fossil genera of the Myctophidae are known to be characterized by considerably more numerous vertebrae. For example, most of the Miocene species from the genera *Myctophum* and *Lampanyctus* have over 35 vertebrae (Arambourg, 1925, 1927), (David 1943). The length of the vertebrae, both caudal and precaudal, exceeds their depth. The ribs are long, with the ends nearly reaching to the ventral margin of the body. The first pair of ribs is much shorter than the subsequent ones (Fig. 9). The vertebral column terminates in an upraised urostyle. The exact number and shape of the hypurals cannot be stated owing to the bad state of preservation.

Delicate, paired intermuscular bones, placed at an acute angle to the bodies of the vertebrae, are observable along the whole dorsal length of the backspine. On the ventral side, these bones are seen only in the caudal part of the body. In addition to these, poorly developed intermuscular bones, subparallel to the bodies of the vertebrae (Fig. 9) may be seen on either side of the vertebral column within the caudal area.

The pectoral fins are rather short (but their length is subject to specific variability), consisting of 12—15 fine rays; only seldom can their exact number be determined.

The ventral fins consist of 8 thick rays, not always readily discernible. Their position varies specifically. The length of these fins could perhaps be regarded as of a systematic character, but owing to the bad state of preservation of the majority of remains here investigated their actual length can hardly be determined. Judging, however, from the best preserved specimens, we may suppose that they did not attain the beginning of the anal fin.

The dorsal fin begins always just a little before the mid-body. It consists of 11—12 rays, relatively thick and in length as follows: first and last ray almost equal, the second ray is the longest, while the subsequent ones are gradually reduced (Fig. 9). All the rays, the first one excepted, have bifurcating ends. The interneuralia which support the rays are thin; the 3 first rays are longer and more obliquely placed in relation to the dorsal margin of the body. In all the representatives of the genus *Eomyctophum* Danil., regardless of species, two free interneuralia have been noted before the beginning of the dorsal fin. The last ray of this fin is not supported by a corresponding interneuralium.

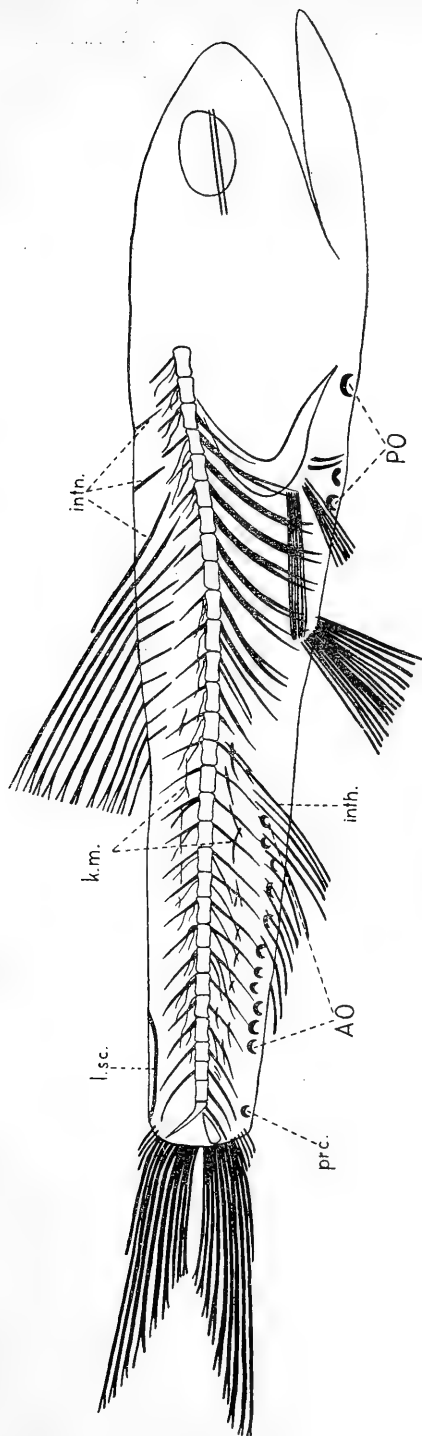


Fig. 9. *Eomyctophum* cf. *koraensis* Danil (after specimen 103 Os.);

AO annal organ, *inh.* interhaemale, *intn.* interneurale, *k.m.* intermuscular bones *l.sc.* luminous plate, *P.O.* thoracic organs, *prc.* precaudal organ; ca. x 4.4.

The anal fin always occurs behind the dorsal fin. The distance between the last ray of the dorsal fin and the first ray of the anal fin, as expressed by number of vertebrae, is an index character of a specific kind; in the material here under investigation, it ranges from 0 to 4 vertebrae, while according to Danilchenko (1947) in *Eomyctophum menneri* Danil. it is even represented by 5 vertebrae. The number of rays in the anal fin has no systematic significance; these rays are thinner than those of the dorsal fin, their number ranges from 12 to 13. The interhaemalia are extremely thin; the first are the longest, the subsequent ones are gradually reduced, and in number they are always by one fewer than the rays. The first rays are the longest (though shorter than the longest rays of the dorsal fin), these following are gradually shorter. According to Danilchenko (1947), species from the Caucasus had an adipose fin whose contours have not been observed on the present writer's material.

The caudal fin is rather long, deeply notched, each lobe consisting of 9—10 cardinal rays and of 4—5 shorter side rays (Fig. 9).

The luminous organs have been preserved on our material as large black stains of pigment on the head, the precaudal and the caudal areas. The most distinct among them are the anal organs (AO) and the precaudal photophores (prc.)⁴. The investigation of numerous individuals from the genus *Eomyctophum* Danil. has shown the arrangement of the photophores to be the same on all these specimens, irrespective of species (Fig. 9), though their state of preservation varies so much that at first sight it suggests the semblance of a strongly variable arrangement of such photophores. In the first place, those most satisfactorily preserved have a characteristically crescent shape (Fig. 9), while in many individuals a single photophore gives the impression of two separate stains of pigment. However, a more detailed inspection of several dozen individuals shows that the two stains are the remains of one large photophore. This supposition is confirmed by the discovery of specimens on which two clearly outlined small stains of pigment are seen to be connected by a less distinctly pigmented area (Fig. 10). The two stains result when connected, in a characteristically semilunar shape. Additional evidence in support of the above interpretation is that the number of the „large” photophores is always equal to double the number of the „small” ones.

⁴ The names and symbols for the particular groups of luminous organs within the Myctophidae are given after Parr (1929).

Many individuals, however, indicate a manner of preservation of photophores different from that just described — that is there is a semblance of the occurrence of the photophores in double rows (Fig. 11), similarly, as in the living *Gonostomidae* or in the genus *Neoscopelus* Johnson of the *Myctophidae*. However, among the numerous specimens whose photophores are thus arranged, forms have been encountered which suggest that we are dealing here merely with a different manner of preservation of an arrangement pattern which is typical of the genus *Eomyctophum* Danil. One row might represent traces of luminous organs

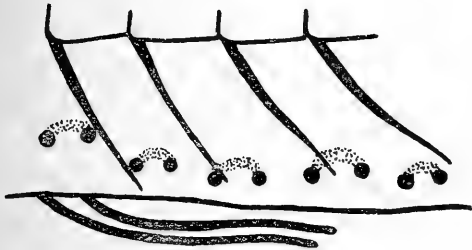


Fig. 10. *Eomyctophum* cf. *koraensis* Danil. luminous organs (after specimen 101 Os.), ca x 10.

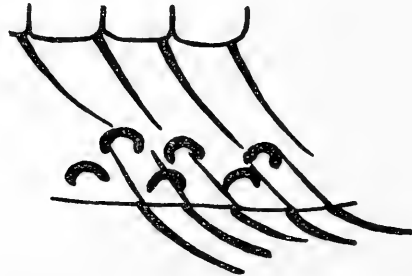


Fig. 11. *Eomyctophum* cf. *koraensis* Danil. luminous organs (after specimen 101 Os.), ca x 10.

of the right side, the other those of the left side of the body. This interpretation seems the most probable, although it has not as yet been possible to clear up why on some specimens these organs are preserved as traces occurring on one side only, while on others they are present as pigment stains on both sides of the body. Note that the one-row and the two-row arrangement of the luminous organs has been encountered by the writer in her material in both species of the genus *Eomyctophum* Danil. described below.

Figure 9 shows a typical arrangement of the photophores. From 1—2 precaudal (prc.) organs occur close together, quite near the base of the caudal fin; the organs of the anal row (AO) follow at a short distance, (usually below the 4th or 5th vertebra from the back). The latter form one continuous row which terminates above the first rays of the anal fin. The last organs of the anal row, which occur beyond the fin — usually 4, occasionally 3 in number — are marked AO posterior, the remainder as AO anterior. These latter always consist of 5—6 photophores, arranged on about the same level, and of 3 (occasionally 2) photophores placed slightly higher than the remainder. The supraanal (SAO) photophores do not occur at all. This arrangement of

the anal photophores approaches that in the recent species *Myctophum anderssoni* Lönnberg; in this form, the supraanal (SAO) organs are lacking (Norman, 1930), while out of the 14—15 anal (AO) photophores the first two occur higher up than the rest. *Eomyctophum* Danil. displays certain differences in this respect, since there are only 10—13 anal organs (AO), of which the first 2—3 are elevated.

Of the remaining precaudal photophores, 4—5 ventral organs (VO) may be noted in some specimens, placed in a single row between the base of the ventral fins and the beginning of the anal fin. Moreover, on some specimens 1—3 traces of photophores of the thoracic row (PO) are to be observed immediately behind the head, and the margin of the abdomen.

In the precaudal area of some individuals, we may observe, in addition to the photophores here described, a number of similar black spots. They occur either all over the body, or dorsally only, as well as on the gill covers (Fig. 7). It is supposed that their presence on the head is confined to places covered with scales. Two possible interpretations of these black stains may be advanced:

(1) analogously as in the living species of the Myctophidae (*Lampanyctus longipes* and *L. alatum*; Brauer 1906) they might be minute luminous organs, or

(2) they might merely be the traces of some slight pigmentation not associated with the presence of photophores. A clarification of the origin of these tiny stains calls for the discovery of better preserved photophores in forms not destitute of scales. Such photophores should, moreover, be represented not merely by a pigment cup but by complete glands as in the Miocene species of the genus *Myctophum* (Arambourg, 1921, 1925) or in the Oligocene species of the genus *Diaphus* (Kalabis 1948).

Another interesting occurrence of pigment is its accumulation as a narrow dorsal band, close to the base of the caudal fin (Fig. 9). By analogy with the recent forms, it might in turn be supposed that we are dealing here with pigment remains such as are encountered in the same place on the luminous plate in representatives of the recent species of the genera *Myctophum* and *Lampadena*. In *Myctophum*, this plate is also a secondary sexual characteristic, since it is confined to individuals more than 2 cm long, always ventrally in females and dorsally in males (Brauer 1906). Such a band of pigment is present on many of the writer's specimens, but always on the dorsal side.

To conclude the description of the arrangement of luminous organs in our material, it should be mentioned that the presence below the lower jaw of 3 large branchial photophores has been observed by the

writer in both species here considered; they are thus characteristic of all the living Myctophidae.

An analysis — as given above — of the arrangement and number of luminous organs within the genus *Eomyctophum* Danil. reveals no essential differences between these two species. Yet the importance of the luminous organs — particularly of the anal group — as a specific character within the genus *Myctophum* is very strongly stressed by Brauer (1906), when dealing with the systematics of the recent Myctophidae. In Brauer's opinion, the number of the luminous organs varies, but the range of variability may be correlated with particular species (*l. c.* p. 159). Hence, the arrangement of the luminous organs might indicate that — independently of other morphological differences — all the specimens are conspecific. This concept would also be confirmed by the presence of forms displaying features which are evidently transitional from *Eomyctophum menneri* Danil. to *E. koraensis* Danil. The writer will return later to this subject.

Eomyctophum menneri Danilchenko, 1947

(Fig. 7)

1947, *Eomyctophum menneri* Danil.; P. G. Danilchenko

Ryby semeistva Myctophidae. p. 195, Fig. 2.

Material. 48 skeletons, including 32 which are complete. Table 5 shows the dimensions of the six best preserved specimens, among which No. 111. Os. is the smallest and 133. Os. the largest.

Description. The maximum body depth is subject to strong variations. Yet the predominant depth — in 25 specimens out of the 32 complete ones — represents 20 to 27 percent of the body length without

Table 5

Dimensions of *E. menneri* Danil. (in mm)

Dimensions	133. Os.	111. Os.	17. Os.	33. Os.	51. Os.	107. Os.
Length of body without caudal fin	37.3	13.7	33.0	31.7	30.9	25.9
Greatest depth of body	9.0	3.1	7.4	6.0	6.4	5.5
Length of head to posterior margin of operculum	13.7	5.1	13.4	11.2	11.1	9.8
Preorbital area	—	2.6	2.2	1.9	2.7	2.4
Horizontal diameter of orbit	—	1.2	3.2	2.8	2.3	1.9
Predorsal area	17.3	6.7	—	14.8	14.7	11.9
Preanal area	28.4	10.4	24.7	22.6	23.3	18.8
Preventral area	21.7	8.0	19.3	17.2	18.4	14.8
Length of caudal fin	11.5	4.5	10.2	8.2	ca.8.9	7.0

the caudal fin. Among the remaining specimens, three represent 17—18 percent and three 29—33 percent respectively. The length of the head represents 33—41 percent in 31 specimens and 43 percent in a single specimen only. According to Danilchenko (1947), this species is characterized by a small eye whose diameter is equal to the preorbital area. In the material here described, this distance is slightly smaller than the orbital diameter although on some specimens these two figures are in agreement.

The vertebral column consists of 31—32 vertebrae of which 15—17 occur in the caudal area. On specimens of this species from the Caucasus, Danilchenko (1947) notes always 32 vertebrae.

The pectoral fins have the longest rays hardly reaching to the base of the rays of the dorsal fins.

The ventral fins occur in a position very characteristic of this species. They lie at mid-base of the dorsal fin or just beyond its center (under the 19th—20th vertebra, from the end); the preventral area represents in 24 specimens 54—59 percent of the body length without the caudal fin, in 4 specimens 50—53 percent, in 2 specimens 60—62 percent.

The dorsal fin consists of 11—12 rays. It begins before the mid-body, above the 21st—24th vertebra (from the end). The predorsal area represents 43—49 percent of the body length without the caudal fin, but in 21 specimens only 45—47 percent, similar to the form from the Caucasus. The length of the dorsal fin corresponds to 6—7 precaudal vertebrae, and always exceeds that of the base of the anal fin.

The anal fin consists of 12—13 rays. Its orientation in relation to the dorsal fin is the most characteristic feature of this species. In 28 specimens, the preanal area represents 70—76 percent of the body length without the caudal fin, as against 72—75 percent in the Caucasian form, and 68 and 77 percent respectively in two specimens. In the remaining two specimens, it was impossible to measure the preanal area owing to the bad state of preservation of the anal fin. The beginning of the latter usually occurs at a distance of 3—4 vertebrae from the last ray of the dorsal fin, below the 12th—13th vertebra (from the end), while in the Caucasian forms this distance corresponds to 4—5 vertebrae (Danilchenko 1947).

The caudal fin is shorter than that in forms from the Caucasus, which have the longest caudal rays equal to the length of the head.

General remarks. The most significant characteristic in this species is the position of the ventral fins, while the distance from the last ray of the dorsal fin to the first ray of the anal fin, and the number of vertebrae, varies but little. In this respect, the specimens described

above resemble *Eomyctophum menneri* Danil.; indeed, the small differences concerning the number of vertebrae and the distance from the end of the dorsal fin to the beginning of the anal fin, fits into individual variability. This seems all the more probable since the material at Danilchenko's (1947) disposal was smaller than ours.

Eomyctophum cf. *koraensis* Danilchenko, 1947

(Figs. 8—13; Pl. III, Fig. 2)

1947. *Eomyctophum koraensis* Danil., P. G. Danilchenko, Ryby semeistva Myctophidae..., p. 194, Fig. 1

Material: 77 skeletons, including 42 complete.

Description. Table 6 shows the body dimensions of 6 specimens in the best state of preservation. The maximum body depth represents in 25 individuals 19—24 percent of the body length without the caudal fin; in 16 individuals it represents 25—32 percent, and in 1 individual 35 percent. In 40 specimens and 2 specimens respectively, the body length without the caudal fin represents 32—38 and 30—31 percent. The orbital diameter always exceeds the preorbital area.

Table 6

Dimensions of *E. cf. koraensis* Danil. (in mm)

Dimensions	5. Os.	3. Os.	147. Os.	103. Os.	16. Os.	152. Os.
Length of body without caudal fin	29.8	20.0	15.0	32.6	28.8	22.7
Greatest depth of body	7.2	5.9	4.5	6.8	6.4	6.4
Length of head to posterior margin of operculum	10.0	7.5	5.0	12.9	10.2	8.4
Preorbital area	2.0	1.6	1.3	2.2	1.8	1.5
Horizontal diameter of orbit	2.6	1.8	1.5	3.0	2.6	1.9
Predorsal area	14.0	10.0	7.2	16.6	13.8	11.2
Preanal area	20.5	—	10.3	24.6	19.3	15.3
Preventral area	14.8	10.0	7.4	18.0	14.2	7.5
Length of caudal fin	8.9	6.8	5.0	10.5	8.8	8.8

The vertebral column consists of 28—30 vertebrae, including 15—17 caudal. Among the material here considered, two specimens only with 32—33 vertebrae have been encountered. Hence, as compared with *Eomyctophum koraensis* Danil. the number of vertebrae is much smaller, since Danilchenko (1947) states that in representatives of this species from the Caucasus there are 33—34 vertebrae. The remains

from Sobniów have therefore been identified as *Eomyctophum* cf. *koraensis* Danil.

The pectoral fins occur just a little lower than at middistance between the ventral margin and the backbone. The longest rays may reach beyond the base of the rays of the ventral fins.

The ventral fins may occur either below the 20-th—22nd vertebra (from the end) — that is below the first rays of the dorsal fin, when the preventral area is equal to the predorsal or they may be shifted further back. The preventral area represents on 20 specimens 48—51 percent of the body length without the caudal fin, on 19 specimens 52—58 percent, on 2 specimens, 46—47 percent, and on 1 specimen 62 percent.

The dorsal fin consists of 11—12 rays. The predorsal area represents 45—50, 42—44 and 52 percent of the body length without the caudal fin in 35; 6 and 1 specimens, respectively. In the Caucasian form — 48 percent. The first ray occurs above the 21st—23rd vertebra (from the end).

The anal fin consists of 12—13 rays. Its beginning occurs below the 13th—15th vertebra (from the end) and is situated immediately behind the last ray of the dorsal fin (Plate III, Fig. 2), or it may be shifted by the distance of 1—2 vertebrae further back (Fig. 9). The preanal area represents in 35 specimens 67—73 percent of the body length without the caudal fin (70 percent in the Caucasian form), in 3 specimens it is 64—65 percent, and in 2 specimens 75 and 86 percent.

The caudal fin is longer than in the preceding species; in some individuals, it exceeds the length of the head.

General remarks. The fundamental differences between the Sobniów remains and the Caucasian form of *Eomyctophum koraensis* consist in the number of vertebrae (as already indicated), and in the marked variability of such characters as the distance from the last ray of the dorsal fin to the beginning of the anal fin; also, the position of the ventral fins. In the Caucasian forms, the latter always occur below the beginning of the dorsal fin.

The descriptions given above reasonably suggest that in the Sobniów material the difference between *E. menneri* Danil. and *E. koraensis* Danil. is far less marked than might be supposed according to Danilchenko (1947). This is particularly well shown by inspection of such a feature as the distance from the last ray of the dorsal fin to the beginning of the anal fin. In forms from the Caucasus this distance, expressed by the length of the precaudal vertebrae, is 1—1.5 vertebrae in *E. koraensis* Danil., but 4—5 vertebrae in *E. menneri* Danil. In the material from Sobniów, on the other hand, forms are encountered which

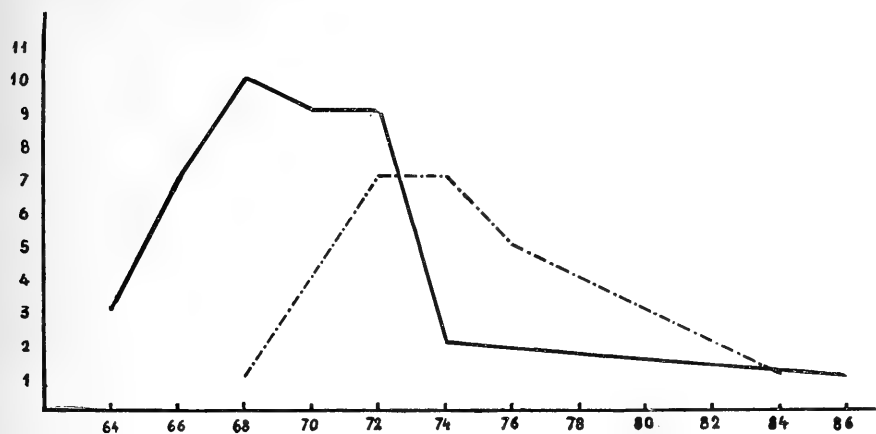


Fig. 12. Variation curve of preanal area expressed in percents of body length without caudal fin; continuous line — *Eomyctophum menneri* Danil., broken line — *E. cf. koraensis* Danil., x number of individuals, y percent value of character.

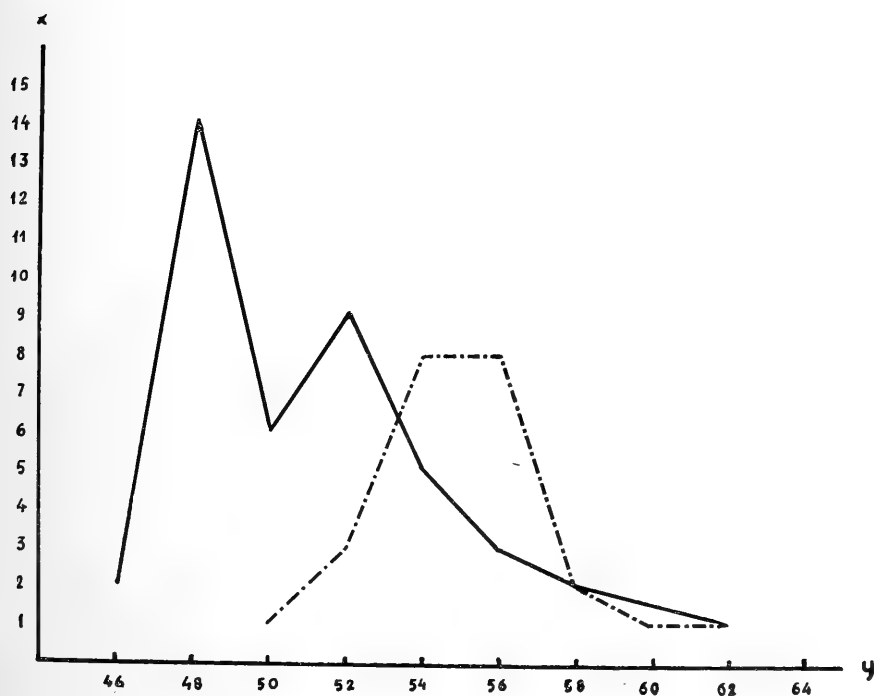


Fig. 13. Variation curve of preventral area expressed in percents of body length without caudal fin; continuous line — *Eomyctophum menneri* Danil., broken line — *E. cf. koraensis* Danil., x number of individuals, y percent value of character.

are clearly transitional. For example, the beginning of the anal fin may occur immediately behind the last ray of the dorsal fin, or be shifted farther back by 1—2 vertebrae in *E. cf. koraensis* Danil., and by 3—4 vertebrae in *E. menneri* Danil.

In view of these distinct passages in the fundamental specific characters, as also in the lack — mentioned above — of structural differences in the organs of the anal group in both species of genus *Eomycotophum* Danil., they should perhaps be regarded as conspecific though subject to strong variations concerning the position of the anal fin and the ventral fins. This supposition is supported by the variations curves (Figs. 12, 13) plotted for the variability range of the position of the anal and ventral fins in *E. menneri* Danil. and *E. cf. koraensis* Danil. The position of these fins is expressed as a percentage of the body length without the caudal fin as represented by the preanal and the preventral areas. Although the mean value of the two indices displays differences, yet their variability ranges partly overlap.

Order **Perciformes**

Suborder **Percoidei**

Family **Carangidae**

Genus *Equula* Cuvier, 1815

Equula ? sp.

(Fig. 14; Pl. IV, Fig. 1)

Material: one incomplete specimen, with head skeleton well preserved; of the trunk — only the scales and rays of fins.

Dimensions (in mm)

Body length without caudal fin	24.4 + ?
Maximum body depth	11.7
Length of head to posterior border of operculum	7.8
Horizontal diameter of orbit	3.8
Predorsal area	11.6
Preanal area	17.7

Description. The body of this fish was rather deep; the maximum depth probably represented about 50 percent of the body length without the caudal fin. The dorsal profile is almost straight, while the ventral is arcuate (Plate IV, Fig. 1). The head is short, deep, the orbit relatively large (Fig. 14).

The skull. A high occipital crest, and the parasphenoid which trav-

erses the lower part of the orbit, are the most distinct among the neurocranial bones. The gill covers are also satisfactorily preserved; the structure of the lower border of the preoperculum is a specific index character in recent species of genus *Equula* Cuvier. On the specimen here considered, the lower border of the preoperculum has rather strong spines, of which only three (Fig. 14) are preserved. Traces of scales are detectable on the operculum, suboperculum and interoperculum. Moreover, minute conical denticles are seen on the preserved fragment of the premaxillary.

The vertebral column unknown.

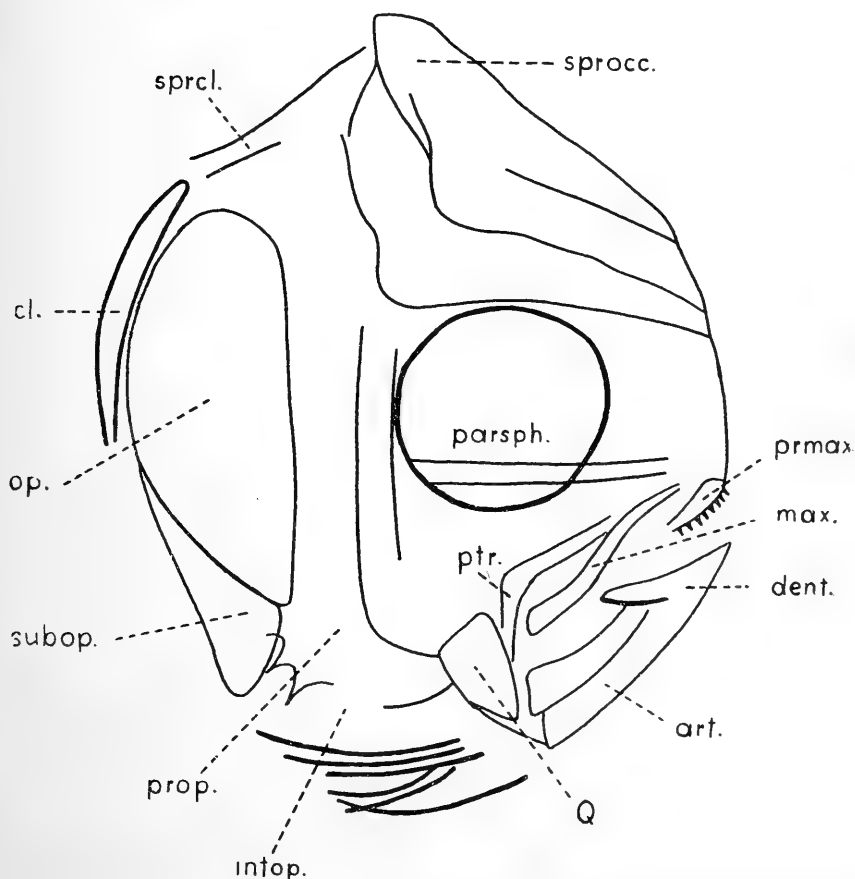


Fig. 14. *Equula* Cuv., skull (after specimen 196. Os.). ca. x 9.5. art. articulare, cl. cleithrum, dent. dentary, intop. interoperculum, max. maxillare, op. operculum, parsph. parasphenoideum, prop. praeoperculum, prmax. praemaxillare, ptr. pterygoidum, Q quadratum, subop. suboperculum, sprcl. supracleithrum, sprocc. supraoccipitale.

The pectoral fins consist of about 13 short rays.

The ventral fins have one strong spine 4.5 mm long, and 5 rays. Their base occurs vertically below the first spine of the dorsal fin.

The dorsal fin consists of 9 spines of the following dimensions: 1st — weakest and shortest — 2.1 mm; 2nd—3.5 mm; 3rd — though broken off at the end was perhaps a little higher or at least as high as the next one; 4th— 4.9 mm; 5th—8th are gradually reduced, while the 9th (last) is slightly longer than the 1st, being 2.6 mm. The length of the 2nd dorsal spine represents 30 percent of the body depth at the beginning of the dorsal fin, while the length of the 4th spine represents 43 percent of that depth. The other dorsal fin consists of about 17 soft rays whose length could not be determined owing to the bad state of preservation. The interneuralia are unknown here; very faint traces indicate the presence in front of the 1st dorsal spine of one, possibly two, free interneuralia.

The anal fin begins vertically more or less below the 3rd ray of the 2nd dorsal fin. It consists of three strong spines, respectively 1.9 mm, 3.3 and 3.3 mm in length. In addition to these spines in the anal fin, there are also 14 soft rays. Interhaemalia unknown with the exception of the first which is rather long. The whole body is covered by small, well preserved cycloidal scales, with distinct minute striae.

General remarks. The form just described comes closest to genus *Equula* Cuvier in shape of body and skull, and most particularly because of the presence of a high occipital crest, the occurrence of minute teeth conforming in size, and also in the structure of the anal fin and scales. It differs, however, from many recent species, and from the fossil species *Equula altapinna* Weiler, in the structure of the lower preopercular border as well as in that of the dorsal fin. The most marked difference consists in the lack of a small triangular expansion in the lower posterior corner of the preoperculum, which is characteristic of the genus *Equula* Cuvier (Hess, Weiler 1955). As regards the structure of the dorsal fin, the Sobniów specimen has 9 spines instead of 8, and the longest of them is not the second but the third. Günther (1860) states, however, that there are 10 spines in the dorsal fin of *Equula longimanus*, and that the second of these spines attains only one third of the length of the third. Hence it seems that, in spite of size differences of spines in the dorsal fin as compared with the majority of species of genus *Equula* Cuvier, the Sobniów form may reasonably be assigned to this genus.

In the fossil condition, the genus *Equula* Cuvier is monotypic, being represented by *E. altapinna* Weiler from the Middle Oligocene septarian (Septarienton) clays in the vicinity of Basle (Hess, Weiler 1955).

Suborder **Scombroidei**
Family **Cybiidae**
Genus *Sarda* Cuvier, 1829
Sarda sp.

Material. A fragment of the upper part of the trunk with the dorsal fin.

Description. The first dorsal fin consists of 16 spines; the first spine is about 40 mm long. The second dorsal fin consists of ca 15 rays which bifurcate at the end but not membering. Three small fins are also seen behind these rays. The preserved fragment of the body is about 160 mm in length. Besides the interneuralia there are 18 neuralia observable from about the mid-point of the first dorsal fin to the end of the body fragment preserved.

The above dorsal fin closely resembles that of *Sarda brachycephala* (Leriche), (Fröhlicher, Weiler 1952). The lack of satisfactorily preserved material hampers more accurate specific assignment.

Suborder **Cottoidei**
Family **Cottidae**
Genus indet.
(Pl. IV, Fig. 2)

Material. 7 incomplete skeletons of rather largesized fishes. The dimensions of the most complete specimen are as follows (in mm):

Body length without caudal fin	160.0
Maximum body depth	ca 24.0
Length of head to posterior border of operculum	47.4
Depth of head	32.2

Description. These fish remains are characterized by a long head with a small, rather high placed orbit (Plate IV, Fig. 2). The jaw has large, conical teeth. The teeth and the presence in the alimentary canal of remnants of undigested skeletal parts of Clupeidae indicate the predatory manner of life of these forms.

The vertebral column consists of 30 long, low vertebrae, centrally very much constricted; among this number, there are 12 caudal vertebrae.

The pectoral fins probably consist of 15 rays.

The ventral fins are placed below, and slightly farther back than, the pectoral fins. They consist of one strong spine and 5 rays.

The dorsal fin is double. The first consists of ca 15 spines and begins immediately behind the head. (Very unfortunately it is not complete on any of the available specimens). The 2nd dorsal fin probably begins just behind the last spine and consists of 18 soft rays.

The anal fin is placed far back since it begins approximately below the 5th ray of the soft dorsal fin (under the 11th vertebra from the end). It consists of more than 15 soft rays.

General remarks. A more accurate identification of the above remains is hardly possible owing to their poor state of preservation. Their assignment to the Cottidae seems reasonably justified on the following characteristics: lack of spine in the anal fin, presence of two dorsal fins (the number of spines being smaller than that of the soft rays in the dorsal and the anal fins), also the lack of scales, large size of head, narrow body and number of vertebrae. The Cottidae, which have only a few fossil representatives, are known as early as from the Eocene (Woodward 1901).

PALEOBIOLOGICAL CHARACTERISTICS OF FAUNA FROM THE JASŁO SHALES

Three distinct quantitative groups are readily distinguished among the ichthyofauna from the Jasło shales:

(1) forms with luminous organs from the Sternoptychidae and Myctophidae; they occur in great abundance and constitute 76.8 percent of the collected material;

(2) the less numerous specimens of the Gonostomidae and Clupeidae which constitute 19.8 percent of our material;

(3) the Cottidae, represented by very few specimens; together with some detached specimens of the genera *Equula* Cuv. and *Sarda* Cuv., they constitute 3.4 percent of the whole material.

Group 1 obviously yields the most substantial information concerning the paleobiological character of our fauna. The living forms of both the Myctophidae and Sternoptychidae are bathypelagic fishes. The recent representatives of the Myctophidae occur at a depth of 150 m (Taning, 1918), *vide* Bertin, Arambourg, 1958) those of the Sternoptychidae live at between 300 and 600 m (Jespersen, Taning, 1926; *vide* Bertin, Arambourg 1958); at night-time, they keep near the surface of the water. According to Brauer (1906), living representatives of the Sternoptychidae may be encountered at far greater depths than the

forms so far mentioned. For example, the depth frequented by genus *Polyipnus* Günther probably ranges from 371 to 1,200 m, while a specimen of *Argyropelecus affinis* Garmann, another representative of that family, was caught at a depth of 1,900 m, with a sea-floor of 3,396 m. Hence, these two families may be regarded as typical deep-sea forms.

Group 2 from the Jasło shales contains fishes whose ecological requirements are more uniform. The Clupeidae occur in both deep- and shallow-sea waters, and even off-shore. The Gonostidae are represented in the Jasło shales from Sobniów by a genus having no corresponding living forms. Other genera of this family, however, do occur in the Atlantic, the Indian, and the Pacific Oceans, also in the Mediterranean Sea (Norman 1930).

In group 3, the Cottidae display highly disparate ecological forms. Owing, however, to lack of reliable systematic assignments of the fossil forms, their ecology is still a blank. The only sound indication is provided by their predatory mode of life; since they preyed on the Clupeidae, it is very likely that they lived in similar conditions. The same is most probably true of the genus *Sarda* Cuv, a predatory form well known in the recent ichthyofauna. *Equula* Cuv., the last of the genera referred to above at present inhabits off-shore regions, occasionally even flows upstream into river estuaries (Günther 1860). Since however, only a single specimen is available in the Sobniów material, this form should be regarded as a purely incidental element.

It is, unfortunately, impossible to clarify the stratigraphy of the Jasło shales on the basis of their ichthyofauna. Most of the Sobniów forms represent groups either inadequately known in the fossil state (Gonostomidae, Sternoptychidae, Cottidae), or such as the Myctophidae which have been previously described mainly from the Miocene (Arambourg, 1925, 1927), (David 1943). *Clupea sardinites* Heck., commonly regarded as Oligocene in age (Weiler 1932); (Pauca 1943), is the only form in our material with a wide paleogeographic range and an important stratigraphic value. It is encountered in menilitic shales as well as in the Jasło and the disodil shales. In view of the marked interest shown in geological literature concerning the mutual relations of the Jasło and the menilitic shales, these deposits should be compared on the bases of existing ichthyofauna descriptions.

No up-to-date descriptions of fish remains from menilites in the Flysch of the Polish Carpathians are available, but the writer's field studies and a revision of her earlier systematic assignments permit her to determine the striking differences between the ichthyofauna from the Jasło shales and that from the menilite shales. These differences

consist in a predominance within the menilites of the Clupeidae and Gadidae — never recorded from the Jasło shales — and also in the rarity of forms with luminous organs (Pauca, 1931, 1933, 1934), (Kalabis 1948), (Horbacz 1957). Apart from differences concerning faunal composition, the mode of preservation of the fish remains also differs. Among the menilites, in addition to complete specimens we may often encounter shale layers some tens of centimeters thick, where detached scales, vertebrae, and opercular bones are crowded in enormous abundance. This points to facial conditions completely different from those associated with the sedimentation of the Jasło shales. The menilite shales are in fact regarded as shallow-sea deposits (Pauca 1934).

It is interesting to note the discovery in the Jasło shales of Rumania⁵ — in the bed of the Bicaz stream and to the east of Covasna — of fish scales or even complete skeletons. These belong to fishes known, after Bancil, from menilite shales (Wdowiarz 1959). Hence, Bancil supposes that within the Tarcau zone the Jasło shales are an equivalent of the menilitic series. The results derived from investigation of ichthyofauna from the Jasło shales of Sobniów provide little to support Bancil's supposition. Further conjectures cannot be based on this evidence until the paleontology of the forms considered above is described in detail; this particularly in view of the additional comparative material which will be derived from descriptions of the ichthyofauna from the Jasło shales whose occurrence has been reported from the Soviet Union and from Rumania (Wdowiarz 1959).

BIOSTRATONOMIC ANALYSIS OF MATERIALS

The lack of scales on most specimens, with the exception of individuals belonging to the genera *Clupea* L. and *Equula* Cuv., is a characteristic feature of the preservation of the fish remains in the Jasło shales. On all the remaining forms, the scales have been preserved merely as more or less distinct traces. In spite of the absence of scales on the distinct majority of individuals, no accumulation of scales has ever been reported from the Jasło shales. Within the menilite shales, on the contrary, are layers densely crowded with scales, although the majority of fish remains there are likewise reported as destitute of scales. In fact, the writer has succeeded in discovering among the Ja-

⁵ In Rumania the Jasło shales are referred to as "marno-carcarele" (Wdowiarz 1955).

sło shales from Sobniów only very few detached scales of the genus *Clupea*.

The following 5 types of manner of preservation have been distinguished in the material considered here:

(1) undeformed straight skeletons (Plates II, III) constitute 67.8 percent of the entire material — 33.8 percent of that figure belong to the Myctophidae, 26.2 percent to the Sternoptychidae, 4.5. percent to the Gonostomidae;

(2) forms slightly curved (Plate I, Fig. 1) constitute 20.1 percent, (Myctophidae 13.3, Gonostomidae 5.7, Clupeidae 1.1 percent);

(3) forms displaying stronger deformations (Plate V) constitute 3.6 percent (Sternoptychidae 0.3, Gonostomidae 1.9 percent);

(4) detached skulls (Plate VI) constitute 7.5 percent (Sternoptychidae 2.6, Clupeidae 4.9 percent);

(5) one headless bodytrunk = 0.9 percent.

The presence in the Jasło shales of various conditions of preservation agrees with the information on other fossil ichthyofaunas presented by numerous authors; according to these suggestions, the following interpretation may be advanced for each of the groups mentioned above.

Group 1. Deformation is completely lacking in most representatives of the Sternoptychidae — fishes of a considerable body-depth. This confirms Weiler's (1929) opinion that the post-mortem bending of the axial skeleton usually occurs only in fishes with a low body-depth. By contrast, in fishes with a deep flattened body, the bending does not occur at all, or to a very small degree.

Group 2. Slight body deformations, expressed by gently arched curvature, occur in the Myctophidae, partly also the Gonostomidae and Clupeidae. In the last named this phenomenon is fairly frequent, being probably due to post-mortem contraction of muscles. An interesting experiment was carried out by Weiler (1929) concerning the post-mortem behavior of the living forms from genus *Clupea* L. He noted that in these fishes deformations follow very soon after death; within 1—1½ days, the head and the forebody bend upwards, within 2—3 days the curvature of the body reaches its maximum, and the abdomen bursts open behind the pectoral fins. If the process of decay is not stopped, the head breaks off, frequently with some portion of the body trunk attached to it.

Group 3. Two causes for the body deformations may reasonably be suggested here:

(a) either natural post-mortem bending, magnified by water current, results in the mutually parallel position of the fore and back

body parts, while the head is bent backwards (Müller 1951) — as seen in a specimen of *Clupea sardinites* (in Plate V, Fig. 1) or,

(b) the water current bends the body in a direction opposite to that normally occurring after death — that is downwards. An example of this manner of preservation is seen in *Idrissia carpathica* — Plate V, Fig. 2.

Group 4. Detached heads of fossil Clupeidae are encountered (Weiler 1929; Pauca 1934) and may be accounted for by the head breaking off owing to a natural post-mortem body curvature. Detached heads of Sternoptychidae have not so far been recorded. Their occurrence, ascertained by the writer, cannot be explained by the same cause as in the case of the Clupeidae, since the Sternoptychidae, which have a high body, are not subject to post-mortem bending. Therefore, the correct interpretation here is possibly that suggested by Hecker and Merklin (1946). These authors suppose that the detached fish heads, present among other fossil remains, may have sunk down to the sea-floor (where they were preserved in the bottom deposits), while the hind part of the body trunk was bitten off by a pursuing predator.

Group 5. Headless bodies are seldom encountered in fossil material. The explanation here may perhaps be that the body was bitten off by a predatory fish, since it bears no signs of deformation or decay.

The biostratonomic analysis of the fish remains examined indicates that the Jasło shales sedimented in a calm sea. Lack of significant body deformations in most of the collected fish remains, and the preservation *in situ* of some scales of Clupeidae, lend support to this supposition. On the other hand, however, even the rare occurrence of strongly deformed fish remains suggests the action of some local bottom currents. At the same time the abundance of fishes with luminous organs excludes a shallow-sea basin, hence also bottom water-movements due to the action of waves. Therefore, it seems reasonable enough to infer that the stronger deformations of skeletons are caused by bottom currents. These currents would, likewise, be responsible for the absence of scales in the proximity of fish skeletons, while the preservation of the pigment in the pigment cup of the various photophores within the skin, together with lack of disruption of the head body bones, certainly indicate an early cessation of decay.

Interesting, too, is the occurrence within the Jasło shales of land plant remains, such as laurel leaves. These leaves must have been transported by surface currents. Fairly large fragments of sea-weeds are also sporadically encountered.

CONCLUSIONS

(1) The composition of the Jasło shales fauna differs very distinctly from the fish assemblage previously recorded from the Carpathian Flysch. *Clupea sardinites* Heck is the only form common to the Jasło and the menilite shales.

(2) According to stratigraphic evidence the presence of *Clupea sardinites* Heck. indicates the Oligocene age of the Jasło shales.

(3) The mass occurrence of bathypelagic fish remains with luminous organs indicates that the Jasło shales sedimented in a deep-sea basin.

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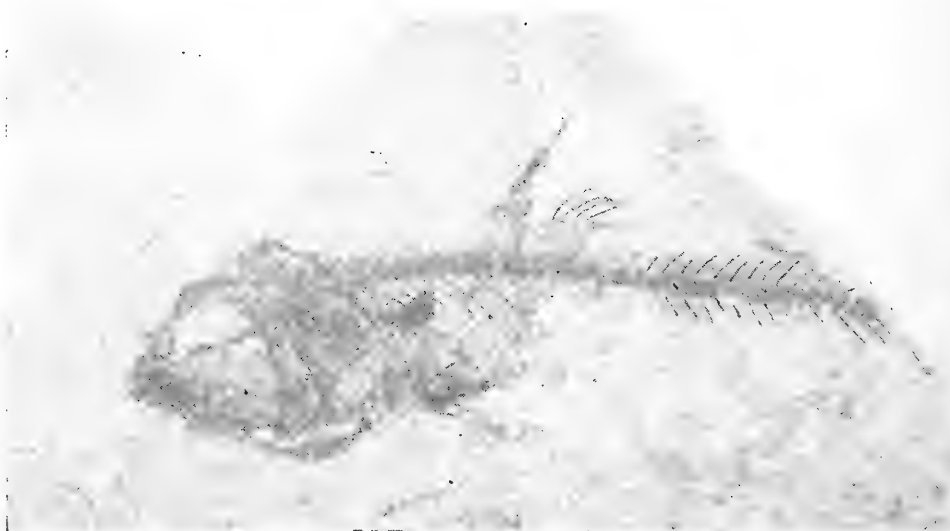
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Translated by M. J. Humnicka



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Fig. 1. *Idrissia carpathica* n. sp. holotype (specimen 164. Os.); ca. x 2.5

Fig. 2. *Idrissia carpathica* n. sp. paratype (specimen 187. Os.); ca. x 2.5.



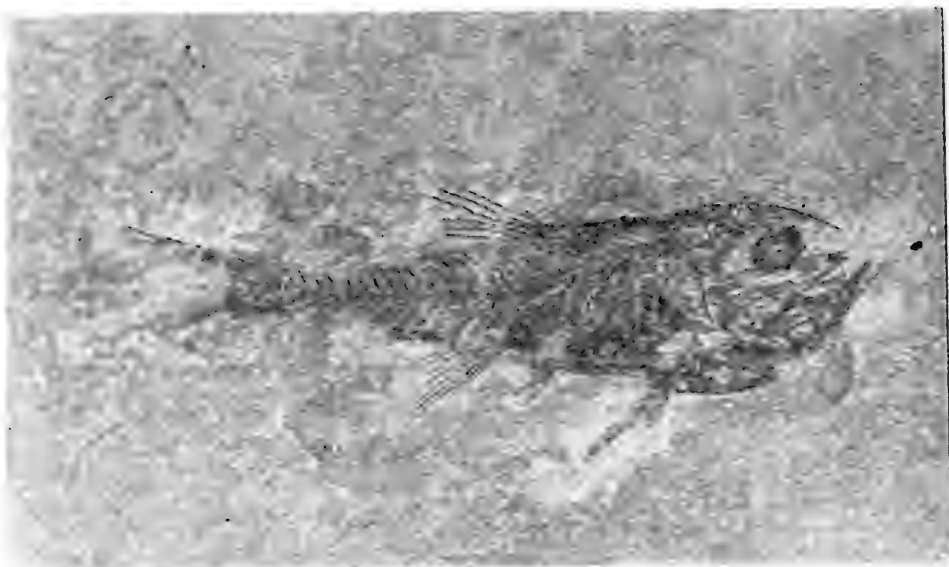
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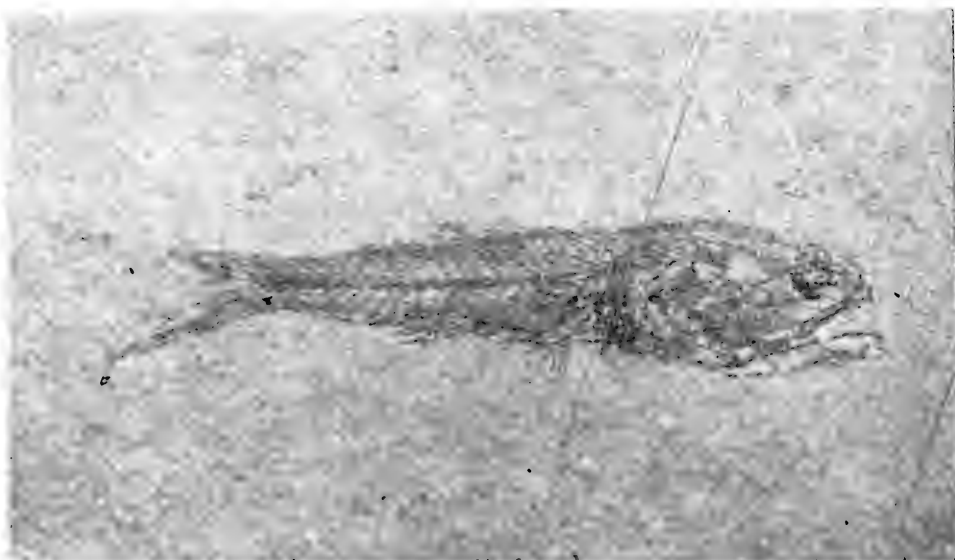
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Fig. 1. *Polyipnus sobnioviensis* n. sp. holotype (specimen 49. Os); ca. x 3.

Fig. 2. *Polyipnus sobnioviensis* n. sp. paratype (specimen 260. Os.); ca. x 4.



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2

Fig. 1. *Polyipnus sobnieviensis* n. sp. paratype (specimen 157. Os.); ca. \times 2.5.
Fig. 2. *Eomyctophum* cf. *koraensis* Danil. (specimen 16. Os.); ca. \times 3.



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Fig. 1. *Equula?* Cuv. (specimen 196. Os.) ca. x 4.5.

Fig. 2. *Cottoidei*, genus indet. (specimen 201. Os.); ca. \times 1.6.



1



2

Fig. 1. *Clupea sardinites* Heck. (specimen 178. Os.); ca x 2.5.
Fig. 2. *Idrissia carpathica* n. sp. (specimen 261. Os.); ca. x 3.

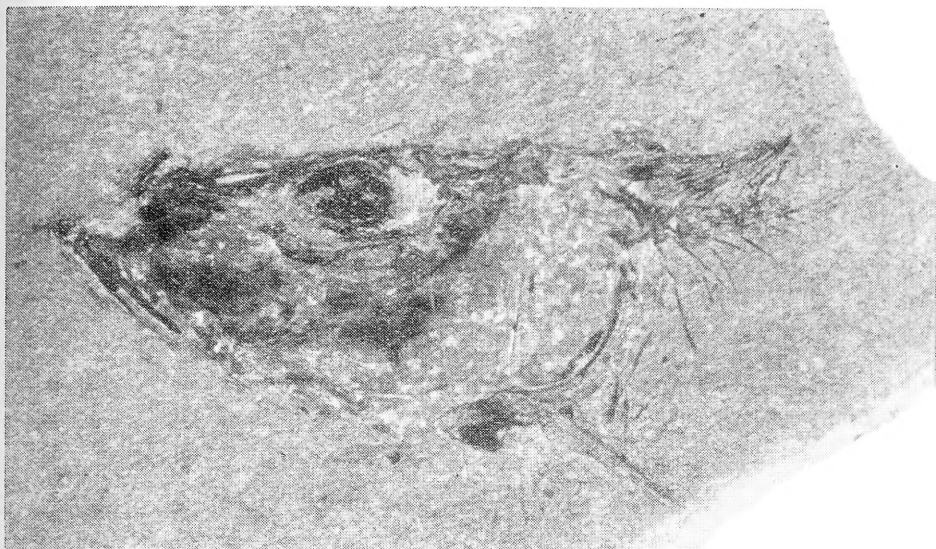


Fig. 1. *Clupea sardinites* Heck. (specimen 169. Os.); ca. x 2.





